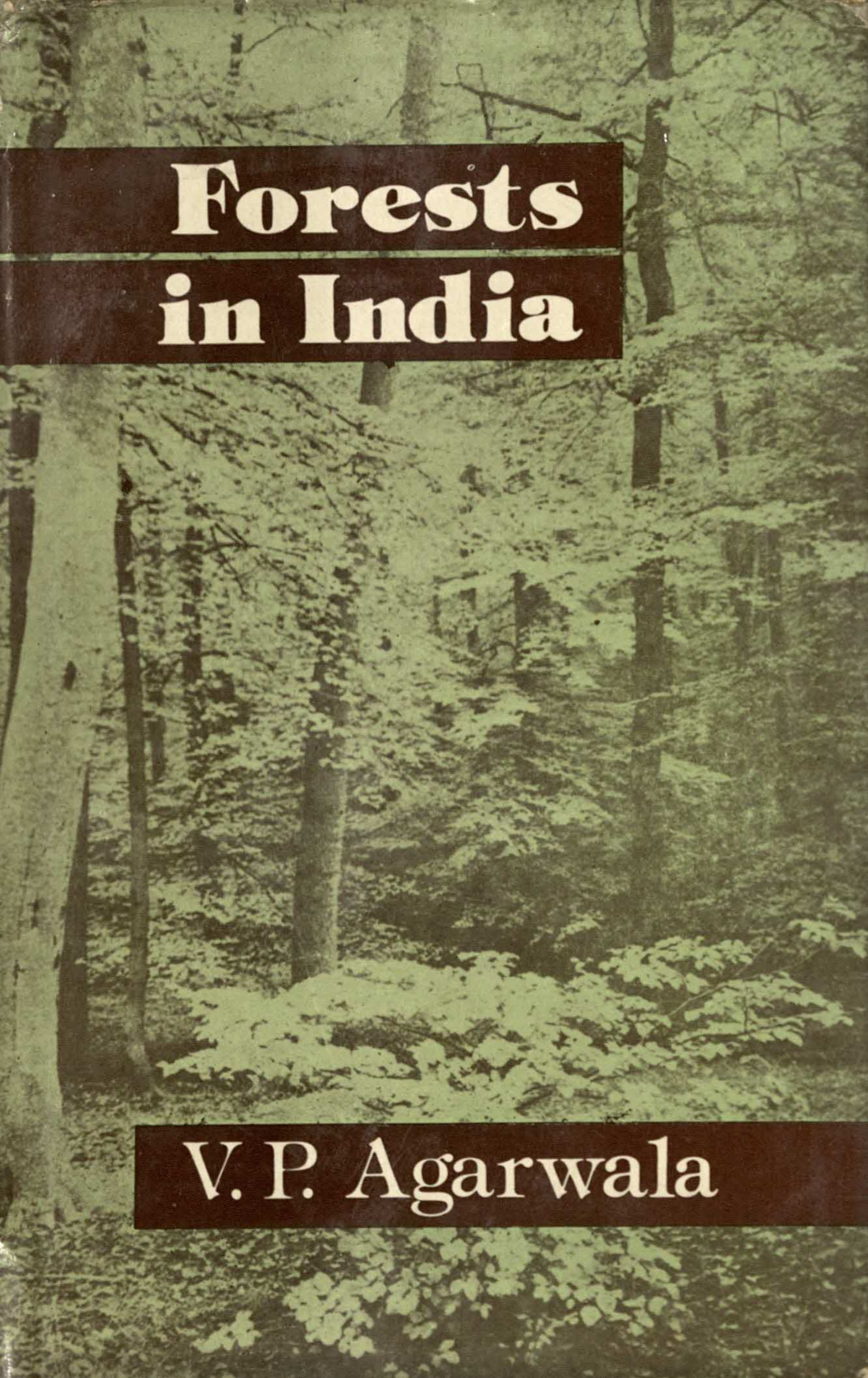

Forests in India

V. P. Agarwala

FORESTS IN INDIA

FORESTS IN INDIA
Environmental and Production Frontiers

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Extract from the message of Smt. Indira Gandhi, Late Prime Minister of India, to the FAO Technical Consultation on wood based panels, New Delhi, January 13, 1983.

The protection and development of forests are necessary for the survival of human civilisation. This does not mean overlooking the productivity role of forests in economic development. Development without destruction and protection with production should be our objectives. Efficient harvesting and utilisation of wood as a forest produce is of prime importance.

* * *   * * *   * * *   * * *

There are mountains in Attica which can now keep nothing more than bees, but which were clothed not so very long ago with fine trees, producing timber suitable for roofing the largest buildings; the roofs hewn from this timber are still in existence. There were also many lofty cultivated trees, while the country produced bountiful pastures for cattle. The annual supply of rainfall was not then lost, as it is at present, through being allowed to flow over a denuded surface to the sea. It was received by the country in all its abundance, stored in impervious potter's earth, and so was able to discharge the drainage of the hills into the hollows in the form of springs or rivers with an abundant volume and a wide distribution. The shrines that survive to the present day on the sites of extinct water supplies are evidence for the correctness of my present hypothesis.

PLATO
Criteas, 400 B.C.

Preface

After spending about seven years in forestry profession in India. I joined an advanced course in the subject at the University of Oxford in December, 1946 along with ten other officers from different States of India, and some serving officers from other countries. A part of the training conducted at Dehra Dun included about eight months of intensive touring all over India. We visited various forests around the country often covering long distance on foot, the longest walk in a day being 46 km. One requirement of the Oxford Course was the adoption of a special subject of study. About half the course time was to be spent on this, besides two months touring, studying forests in France, Switzerland, Denmark and Sweden. The subject I chose was "Forestry in Relation to Land Management in India". A summary of this report was discussed at one of the weekly seminars and received appreciation from several participants and from Sir Harry Champion, then Professor of Forestry at Oxford, who had served in India for many years and has been a leading authority in the history of world forestry. The Report covered the entire pre-partition India; when the Indian group including myself returned to India in September, 1947, the country had been divided. The Report was given finishing touches in India, and submitted to Oxford in December, 1947, but was not published.

Since then, as I traversed most parts of India several times, often visiting areas not seen ordinarily by most people, and other continents, the place of forestry in land use has been one of my major concerns in life—hence this book. India's forests. as of any other country, perform irreplaceable vital functions, both environmental and productive. They moderate extremes of heat and cold, afford protection against strong winds, and prevent soil erosion, reducing run-off, regulating streamflow, reducing siltation of rivers and reservoirs, tending to reduce floods and preventing destruction of agricultural land. They assist in global cycling of water, oxygen, carbon and nitrogen, and house millions of plants which are valuable gene resources. They also provide shelter to wild life and yield wood, bamboo and innumerable non-wood products which are vital for the national economy.

This book discusses the land use and forest area in India, the history of forestry in the country and the ecology of India's forests. It brings out the environmental role of our forests in the context of world experience of climate, and soil and water conservation, and reviews the extent of soil erosion and flood problems of the country. It also considers the production of various wood and non-wood products from our forests, agro-forestry and social forestry, the important forest-based industries and, estimates the employment provided by the Sector. It discusses the important question of our tribal population whose lives are closely interwoven with forests. Our rich wildlife has been dealt upon, besides the vital question of investments in forestry and forest policy.

Forests in India at present are not fulfilling many environmental functions they should. The production from them is also extremely low, compared to the potential. These facts are due to certain social practices and inhibitions, besides the relentless and increasing pressure of population—human and bovine. India has over 100 million hectares of wastelands. National Sixth Five Year Plan does not do justice to our forests and wastelands. Common lands are most uncared for. Major policy decisions are required and sufficient targets need to be laid down for the Seventh and Eighth Five Year Plans in this regard. Close evaluation of such works undertaken in the past is urgently needed; chances of success are best and cost least, if afforestation, soil conservation and animal husbandry programmes are closely integrated, and willing cooperation of people ensured. Involvement of women and children in the programmes is a must, and good voluntary organisations should be given a special status.

I owe special gratitude to many people from whose writings, or discussions with whom, ideas have been drawn. Foremost among them is late Shri S.K. Seth, a close friend for over 30 years, a life long bachelor wedded to forestry only, easily the most outstanding forester of post-independence India, whose demise soon after he retired as Inspector-General of Forests was a serious loss to Indian forestry. Discussions with him at various times and his writings have been of great help to me. I owe very special gratitude to Shri N.D. Bachkheti, Retired Inspector-General of Forests, India, who took great pains in going through the original manuscript, and made valuable suggestions. The responsibility for facts, views and mistakes where any, however is mine. Discussions with and/or writings of the world famous scientist Dr. M.S. Swaminathan, Dr. Kamla Chowdhry, Dr. T.N. Khoshoo, Dr. David Seckler, Dr. D.R. Bhumbla, Dr. Lincoln C. Chen, Sarvashri B.B. Vohra, C.L. Bhatia, L.H.A. Rego, Dr. W.R. Bentley, Sarvashri R. Venkataraman, N.P. Tripathi, R.K. Mukherjee, Dr. G.R. Gregory, Dr. K.G. Tejwani, Shri K.M. Tewari and Dr. R.V. Singh, were always very useful. Similar help and valuable material was provided by Sarvashri N.J. Joshi, P.N. Gupta, D.N. Tewari, R.D. Gupta, H.S. Panwar, R.N. Loganey, A.V. Ramakrishna Rao, K. Kanungo, J.C. Tandon, Dr. N. Chatterjee, and Shri R.P. Kapoor. Important ideas/information were also collected from Sarvashri D.N. Misra, V.K. Sharma, S.S. Dalal, S. Sankaramurthy, A.N. Chaturvedi, B.K. Bhalla, Om Kumar, M.G. Gogate, Anil Agarwal, Mohan Guruswamy, Arvind Khare, Kamal Sharma, P.C. Chadha and Ms. Martha Avery. Special debt is due to the Ford Foundation and the Society for Promotion of Wastelands Development, my recent work with which organisations gave a sharp edge to many of my ideas.

I owe gratitude to Shri S. Varadarajan without whose intelligent help and hard work as stenographer on holidays, this book would have been impossible. Shri K.R. Raghunathan was always helpful. I hope this book will create essential awareness of major land and environmental problems in relation to our forests, in early decision making on important matters like common and government lands, animal and afforestation policies, in formulation and implementation of connected sizeable time bound programmes, and thus in building up a better, richer and happier India.

V.P. AGARWALA

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List of Abbreviations

Million : m
Million hectares : m ha
Lakh : 100,000
Crore : 1,000,000
Metre : metre
Cubic metre : metre^3
Kilometre : km
Species : spp.
Air dry tonnes : ADT

CHAPTER 1

Introduction

Forests

The word 'forest' is derived from the Latin word '*Foris*' meaning outside, the reference apparently being to a village boundary or fence. Thus, originally, a 'forest' must have included all uncultivated and uninhabited land. Today, a forest is any land managed for the diverse purposes of forestry, whether or not covered with trees, shrubs, climbers or such other vegetation. Technically, forest has come to be defined as an area set aside or maintained under vegetation for any indirect benefits, namely climatic, protective or environmental and/or for production of wood and non-wood products. In the legal sense, a forest can be defined as an area of land notified to be a forest under a forest law.

Ecology and ecosystem

Ecology is defined as the branch of science concerned with the interrelationship of organisms and their environment, especially as manifested by natural cycles and rhythms, community development and structure interaction between different kinds of organisms, geographic distributions and population alterations.

Biome is an ecological formation considered in terms of both plants and animals of an area, and is usually identified in terms of characteristic vegetation forms.

Ecosystem is an ecological community considered together with the non-living factors of its environment as a unit. *Biosphere* is defined as a part of the world in which life can exist and includes parts of the lithosphere, hydrosphere and atmosphere.

Finally, in ecological terms a forest may be defined as a plant community predominantly of trees and other woody vegetation usually with a closed canopy.

Forestry

Forestry concerns the theory and practice of raising tree crops of forests and constitutes their creation, conservation and scientific management and the utilisation of the resulting resources.

Forests are a striking feature of the land surface. The forests of a country are a natural asset of great value, which, unlike mineral resources are renewable and can be kept perpetually protected, productive and useful under proper management.

Forests represent the largest, most complex and most self-generating of all ecosystems. They cover about one-third of the land area of the world and constitute one-half of the total biomass. Forests have a direct and beneficial influence on all parts of the biosphere as a result of their heat absorption capacity and conductivity, aero-dynamic roughness, influence on the water cycle and emissivity in the infrared band. They act as buffer zones between man-made ecosystems and represent half of the world's photosynthetic fixation of carbon from the atmosphere, with its concurrent release of oxygen.

Environment

Environment, literally means the surroundings. In detail this may be defined as the surrounding conditions, and/or forces that influence or modify:

a) the whole complex of climatic, edaphic and biotic factors that act upon an organism or an ecological community and ultimately determine its form and survival; and

b) the aggregate of social and cultural conditions (as customs, laws, language, religion and economic and political organisations) that influence the life of an individual or community.

Habitat

Habitat is defined as a place where a plant or animal species naturally grows and lives, i.e., purely the physical environment of a locality occupied by a living group.

Importance of forests

The importance of forests at the national level lies chiefly in the following aspects:

1) Forests are a major factor of environmental conservation and control extremes of heat and cold, rendering the climate more equable. This effect is particularly marked on the main continental land masses within the tropics as in the north Indian plains where during the long dry seasons the hot dry land surface transfers heat energy to the wind. The denuded, overgrazed and over-cropped areas in such situations increase the desiccation of land immediately downwind. In such circumstances, forests have an appreciable effect on the climate. Forests also tend to increase the relative humidity of the air and retard evaporation. In this way forests afford protection to animals and crops against strong, cold or hot and dry winds, and rays of the sun and prevent desiccation and vegetative retrogression.

2) Forests tend to increase local precipitation, at least to the extent of increasing the number of rainy days. Forests enrich the soil with fallen leaves and debris and increase its depth, porosity and water storage capacity. In hilly country, forests regulate the water supply, feeding springs in dry weather, promoting a perennial instead of a seasonal streamflow and tending to prevent sudden and violent rises of water during rains and floods. Forests help to prevent soil erosion, landslips, shifting sands and silting up and consequent overflowing of rivers, thus reducing the dangers of floods. On level ground, forests have a draining action; the clearing of forests on wet land increases its swampiness, while in arid regions it may increase the salinity of streams.

3) Forests supply timber, fuel, pulpwood, and other varied products, which in turn support major industrial activity in various sectors and provide large-scale employment.

4) Finally, forests are the home of wildlife, and afford important aesthetic and touristic values. They have a vital biological importance as gene reserves because of the flora and fauna associated with them.

Forest destruction

The development of every country has necessarily involved the clearance of its original forests to varying extents whether for the development of agriculture, industries, villages and townships or for communications. Where, however, this process has been carried too far and combined with misuse of land, it has sometimes led to a progressive desiccation of the land. This can not be attributed mainly to a diminution in rainfall, but more to the lowering of atmospheric humidity, exposure to dry winds, increased evaporation, the release of wind blown sands, the removal of fertile top soil by erosion, and interference with the water supply caused by the clearing of forests. Where the rapid regrowth of vegetation is prevented by excessive grazing and fires, the result is a progressive deterioration in the character of vegetation. This is also accompanied by drier conditions of environment, ecological retrogression and some times culminates in almost complete sterility of land.

History shows many instances where countries once fertile and well watered are now impoverished and sterile, where ancient civilisations have disappeared to give place to tracts of rocky outcrop, or barren sand. In many cases this is due to the destruction of the forests which once clothed these areas, aggravated by the misuse of land. The once well-wooded mountains of Spain, North Africa, Italy, Greece and other Mediterranian countries have been undergoing a process of deforestation and denudation during the past 2,000 years. Sicily whose mountains were once clothed with forests was a never-failing granary of Rome, but deforestation and grazing have removed the protective vegetation, eroded and scarred the hillsides, and carved deep gullies which have encroached on the cultivated lands. Impoverishment of the land, with frequent failure of crops is the result. The North African coast tells a similar tale; this once had fertile tracts and flourishing cities which have now given way to desert.

Environment and production from forests

In India forests cover about 75 m ha or about 23 per cent of the entire land area. In order to fulfil their appropriate functions the forestry development in India must proceed at a rate much faster than hitherto for the sake of the entire economy, for the protection and improvement of the environment and for a much greater production of wood and other non-wood products.

Not only should the quality of environment be preserved and improved, but also the economic demand for forest products should be met adequately, both for internal utilisation and for export. A substantial increase in employment in forestry operations is feasible and should be aimed at. It is necessary to emphasise that a close integration of the protective and productive functions of forests should be aimed at which is both feasible and possible.

CHAPTER 2

Land Use, Forest Area and Population

Land use in India

India has a total geographical area of 328.8 m ha, out of which the reporting area is 304 m ha. The main statistics of land use are provided by the annual publication, *Indian Agriculture in Brief* (1982). Table 2.1 gives the actual land use for the year 1978-79 (provisional) for different States and Union Territories.

Forest area

It is seen from Table 2.1 that according to the Agricultural statistics, India has a forest area of 67.4 m ha. However, according to the forestry statistics in the brochure '*India's Forests*', 1980, the area of forests in India in 1978-79 stood at 74.8 m ha. Perhaps some of the area classified as forests by the State Forest Department has been considered as culturable waste or included under other categories by the Revenue Department. It is surprising that contradictory figures of forest area should continue to be issued by the Ministry of Agriculture. Figures of forest area need to be properly consolidated and a single set of figures issued by the Ministry of Agriculture in consultation with the State Revenue and Forest Departments.

Land categories

The various categories of land classification need some clari-

Table 2.1: Land use classification—1978-79 (provisional)
(in '000 ha)

State/Union Territory	Reporting area	Forests	Area put to non-agricultural uses	Barren and uncul-turable land	Perma-nent pastures and other grazing lands	Misc. tree crops and groves	Cultur-able waste land	Fallow lands other than current fallows	Current fallows	Net area sown
1	2	3	4	5	6	7	8	9	10	11
Andhra Pradesh	27,440	6,222	2,134	2,349	948	263	888	1,053	2,234	11,349
Assam[a]	7,852	1,964	882	1,533	185	249	130	122	108	2,679
Bihar	17,330	2,758	1,660	1,008	144	217	468	924	1,619	8,532
Gujarat[a]	18,811	1,969	1,057	2,486	850	4	2,002	414	486	9,543
Haryana	4,404	110	378	73	43	—	36	—	114	3,650
Himachal Pradesh	3,002	827	198	156	1,024	47	136	4	49	561
Jammu & Kashmir	4,674[b]	2,918	333	230	124	102	149	8	86	724
Karnataka	19,070	3,016	1,051	853	1,398	315	530	625	967	10,315
Kerala	3,886	1,082	260	75	6	67	123	27	42	2,204
Madhya Pradesh	44,198	14,205	2,182	2,303	2,877	144	1,849	933	858	18,847
Maharashtra[a]	30,758	5,324	998	1,725	1,592	198	1,021	843	812	18,245

Table 2.1 (*Contd.*)

1	2	3	4	5	6	7	8	9	10	11
Manipur[a]	2,211	602	26	1,419	—	24	—	—	—	140
Meghalaya	2,249	812	84	231	17	145	455	261	51	193
Nagaland	1,042	288	49	N.A.	—	45	—	426	84	150
Orissa	15,540	6,655	557	279	534	489	260	138	531	6,097
Punjab	5,033	217	430	99	3	4	48	—	55	4,177
Rajasthan	34,704	2,023	1,469	2,960	1,834	10	6,882	2,118	1,937	15,471
Sikkim[a]	714	265	70	209	103	4	1	1	—	61
Tamil Nadu	13,001	2,031	1,678	610	161	193	362	448	1,267	6,251
Tripura[a]	1,048	578	—	120	—	98	2	2	2	246
Uttar Pradesh	29,809	5,109	2,218	1,146	298	679	1,338	607	932	17,482
West Bengal[a]	8,849	1,185	N.A.	1,382	N.A.	531	N.A.	212	N.A.	5,539
Union Territories	9,056	7,281	88	251	14	82	268	381	209	482
Total All India	304,681	67,441	17,802	21,497	12,155	3,910	16,948	9,547	12,443	142,938

[a] Data relates to previous years.

[b] Excludes area under unlawful possession of China and Pakistan.

fication. The area under the heading 'not available for cultivation' includes buildings, roads, railways, industries and also includes the area under water. This is not altogether satisfactory as the area under water in many cases can be highly productive for fish culture, etc. The category 'barren and unculturable' covers all barren and unculturable land like steep mountains, snows, deserts, etc., i.e. land which cannot be brought under cultivation except at high costs. The category 'culturable wastes' includes land available for cultivation, either not taken up for cultivation at all or once taken up for cultivation but not cultivated for at least 5 years or more in succession, for one reason or the other. Such lands may be either fallow or covered with shrubs and trees. They may be assessed or unassessed to revenue and may lie in isolated blocks within cultivated holdings. 'Current fallows' comprise of cropped areas which are kept fallow during the current year only, while 'fallow lands other than current fallows' are lands which are taken up for cultivation but are temporarily out of cultivation for a period of not less than one year and not more than 5 years. The reasons for keeping such lands fallow may be poverty of cultivators, inadequate supply of water, climatic problems or unremunerative nature of farming.

Land use in India in 1938-39

Historically, it is important to study the land use in India from pre-partition days. Tables 2.2 and 2.3 give the land use and forest area figures in the undivided India in 1938-39, Table 2.2 being for the then British Provinces and Table 2.3 for the then Indian States. Although figures are incomplete, these figures make interesting reading. In the British Provinces of the undivided India in 1938-39 with a total area of 221.8 m ha, the total Government forests occupied an area of 30.6 m ha, while the private forests covered an area of 14.0 m ha. For the then Indian States against an area of 120.3 m ha, land use figures were available only for 69.5 m ha, out of which forests occupied 16.2 m ha. These figures are based on the *Agricultural Statistics of India*, Parts I and II for 1938-39 published in 1945. If two-thirds of the area of the Indian States for which land use figures were not published be assumed to be forest, this would add another 33.8 m ha to the forest

Table 2.2: Forest and land use in the British Provinces 1938-39 (in '000 ha)

Sl. No.	Province	Total Area	Forest Area					Grand total forest area	Forest area according to Agril. Statistics	Other uncultivated land excluding current fallows	Not available for cultivation area	Fallows area	Area sown
			Reserved	Protected	Unclassed	Total Government	Private						
		1	2	3	4	5	6	7	8	9	10	11	12
1.	Ajmer Marwar	637	18	—	—	18	—	18	18	18	262	96	113
2.	Andman & Nicobar	649	387	—	178	566	—	566	—	—	—	—	—
3.	Bengal	20,384	1,640	255	1,277	3,173	476	3,650	1,897	2,686	2,686	3,764	10,008
4.	Bihar	17,937	411	171	—	582	1,890	2,473	2,673	2,752	2,487	2,748	7,275
5.	Bombay	19,716	2,737	41	580	3,358	42	3,401	3,367	369	2,311	2,021	11,646
6.	C.P. & Berar	25,497	5,032	—	946	5,979	6,332	12,311	6,432	5,672	1,975	1,598	9,818
7.	Coorg	409	134	—	82	216	89	306	134	4	145	65	60
8.	Delhi	148	—	—	—	—	—	—	—	25	33	20	69
9.	Madras	32,278	3,949	48	841	4,838	3,851	8,690	5,338	4,396	5,854	3,990	12,699
10.	N.W.F.P.	3,415	68	—	49	118	34	152	142	1,160	1,027	237	846

11.	Orissa	8,329	363	185	—	548	436	985	1,067	1,270	2,513	666	2,812
12.	Punjab	24,686	525	846	171	1,544	—	1,544	799	5,777	5,409	2,343	10,357
13.	Sind	12,212	279	19	—	299	—	299	307	2,227	5,584	2,025	2,067
14.	Uttar Pradesh	27,457	1,353	2,237	106	3,697	799	4,496	3,753	4,032	4,017	1,131	14,522
15.	Assam	14,360	1,687	—	3,770	5,457	—	5,457	1,659	7,598	1,852	571	2,678
16.	Baluchistan	13,707	88	—	122	210	—	210	—	—	—	—	—
	Total	2,21,828	18,677	3,807	8,127	30,610	13,955	43,999	27,591	37,990	36,162	21,280	84,976

Notes: 1. Columns (8) to (12) are from *Agricultural Statistics of India*, Part I for 1938-39.
2. Columns (2) to (7) are from *Annual Return of Statistics for Forest Administration of British India* for 1938-39.
3. Figures rounded.

Table 2.3: **Forest and land use in the Indian States—1938-39** (in '000 ha)

Sl. No.	State or States	Area	Area for which figures of land use are not known	Net area for which figures are known	Forests (area)	Other cultivated land excluding current fallows area	Not available for cultivation area	Fallow area	Area sown
1.	Baroda	2,043	—	2,043	184	272	252	—	1,333
2.	Bombay States (9 only)	1,671	200	1,470	73	263	116	85	910
3.	Central Indian States	5,636	629	5,006	716	837	824	527	2,100
4.	Gwalior	6,681	1,498	5,183	717	1,179	1,255	172	1,858
5.	Hyderabad	21,418	1,739	19,679	2,589	742	3,923	1,370	10,948
6.	Kashmir	21,068	17,840	3,228	756	419	1,098	111	862
7.	Madras States	2,768	315	2,453	670	170	265	168	1,217
8.	Mysore	7,638	558	7,080	762	998	2,154	612	2,551
9.	Punjab States	8,611	3,304	5,306	311	1,338	608	588	2,462
10.	U.P. States	1,628	78	1,550	718	111	364	31	323
11.	Eastern State Agencies	16,912	8,469	8,443	8,443	—	—	—	—
12.	Rajputana States	24,172	16,064	8,108	285	1,833	1,632	1,590	2,744
	Total	1,20,253	50,699	69,553	16,229	8,168	12,496	5,257	27,312

area. Thus, it could be considered that there were 94.6 m ha of forest land in the undivided India in 1938-39. Figures of land use, forest area and changes in forest area during the last 50 years by States and districts deserve careful investigation and analysis for proper environmental studies.

Changes in land use and projected changes

Table 2.4 gives the changes in the land use in India during the period 1950-52 to 1977-78 and the projected changes in the years 2000 and 2025, as per the *Report of the National Commission on Agriculture*, 1976. It would be seen that the net area sown increased from 119.4 m ha during the years 1950-52 to 142.6 m ha in 1977-78. According to Table 2.4 the forest area increased from 40.5 to 67.1 m ha during the period 1950-52 to 1977-78. However, these figures do not show the correct position based as they are on the Agricultural Statistics of India. In fact there was no increase in forest area during this period at all, and India lost at least 4.1 m ha of forests during this period.

The projected changes in land use patterns are interesting. With the increase of population and industrial development, increasingly larger areas of arable and other lands will be occupied by industries, roads, railways, etc. The loss of arable area on this account is estimated to be 9 m ha by the year 2000 A.D. compared to the base year 1970-71. The loss of arable area could possibly be made good partly by reclaiming culturable waste, and by reducing the amount of fallow lands, as also by bringing some other areas under cultivation including the desert areas by provision of irrigation facilities. With all these changes the net area sown is expected to rise from 140 m ha in 1970-71 to 150 m ha in the year 2000 A.D. The actual forest area in 1982, though reported officially in 1980 as 74 m ha may not be more than 70-72 m ha. While the NCA projections provide a sizeable increase in the area under agriculture, these do not provide for sufficient increase in the forest area, as is required for environmental conservation. In fact the target should be to increase the forest area at least to 100 m ha, say by the year 2000 A.D. by bringing marginal lands under tree crops, while multiple use of land for agroforestry should be greatly encouraged.

Table 2.4: Changes in land use in India during the period 1950-52 to 1977-78 and projected change to 2000 and 2025
(in '000 ha)

Year	Reporting area	Forest	Non-agrl. uses	Barren and uncul-turable	Cultu-rable waste	Pasture and grazing land	Misc. tree crops and groves	Fallow lands	Net area sown
1950-52	284.3	40.5	15.5	32.0	22.9	6.7	7.9 (51-52)	28.9	119.4
1960-61	298.9	55.8	18.0	32.0	18.6	13.9	4.4	22.6	133.2
1966-67	305.4	62.3	16.4	31.9	16.6	14.3	4.7	22.9	136.3
1977-78	304.9	67.1	17.6	21.4	16.0	12.0	4.0	22.8	142.6
*2000	318.0	70.0	26.0	30.0	9.0	15.0	5.0	13.0	150.0
*2025	318.0	70.0	36.0	24.0	4.0	15.0	6.0	8.0	155.0

*Projected

Natural regions of India

In a country as large as India and with such major differences in physical conditions in its different parts, the problem of land use for proper economic and developmental planning deserves to be considered, specially for the various natural regions. Several schemes have been evolved by economists and geographers for the natural regions, sub-regions and divisions. Among these special mention may be made of the scheme of such divisions by R.L. Singh in the *Regional Geography of India*, and the Planning Commission Study of 1964 by V. Nath.

In *The Regional Geography of India* (edited by R.L. Singh) India is divided into 28 Meso level, 67 First Order, 192 Second Order and as many as 485 Third Order regions, with indications for further lower order regions at places. Of these schemes, the scheme of V. Nath seems particularly attractive. This is based on considerations of physical factors, i.e. geography, soils, geologic formations, climate, land use, and the agricultural and socio-economic factors. It divides India into 11 main natural regions.

LAND USE BY NATURAL REGIONS

While land use by States and Union Territories is important, the actual land use by various natural regions of the country is a far more interesting and useful study. Table 2.5 shows the actual geographical area of different natural regions according to Nath's classification and the percentage under different land uses. The table deserves careful attention. The percentage of net area sown varies from 69.4 per cent in the north Indian plains (except Rajasthan) to 47–54 per cent in the east and west coast plains and in the Deccan. The percentage of net area cultivated drops to 13.5 per cent in the Kutch and the Western Himalayas, and to 2 per cent in the Islands. The percentage of forests in the various natural regions varies inversely to the percentage of land under agriculture. In the north Indian plains except in Rajasthan, forests occupy about 5.8 per cent of the total land area. They are only 2 to 6 per cent in Rajasthan and in the hilly regions of central India and in the Kutch. However, the percentage of forests in the east and west coast plains and in the Deccan varies from about 14 to 18

Table 2.5: Classification of land use (%) by natural regions (1966-67)

Sl. No.	Natural regions	Reporting area in ha	Sites, buildings, communications and waters	Area sown	Pastures and grazing lands	Forests	Culturable waste	Barren and unculturable	Fallow	Groves
1.	N. India Plains except Rajasthan Plains	44.8	7.1	69.4	0.4	5.8	2.9	6.2	6.6	1.6
2.	Deccan	69.9	5.2	52.9	4.6	17.9	2.4	4.6	9.8	2.6
3.	West Coast Plains except Kutch	22.6	6.1	53.9	5.6	18.4	3.1	6.3	4.8	1.8
4.	East Coast Plains	18.4	10.6	46.9	3.6	13.6	6.4	7.4	9.3	2.2
5.	Central Hill & Plateaus except Rajasthan	71.5	5.1	37.7	7.2	29.0	6.3	6.8	7.0	0.9
6.	Assam Valley	6.3	12.2	33.1	3.7	27.8	3.0	10.7	5.6	3.9
7.	Rajasthan Plains Hills & Plateau	34.8	3.6	42.2	5.2	3.3	18.6	14.2	12.8	0.1
8.	Kutch	4.4	0.5	13.5	1.6	2.1	4.6	72.6	5.6	0.1
9.	Western Himalayas	15.2	3.2	13.6	11.1	52.5	2.3	13.5	1.6	2.2
10.	Eastern Himalayas	16.5	0.4	5.0	0.3	48.5	0.1	44.9	0.2	0.6
11.	Islands	0.6	0.3	2.0	0.5	92.9	1.1	2.8	0.2	0.2
	Total All-India	305.5	5.4	44.6	4.7	20.4	5.4	10.4	7.5	1.6

per cent and is 28 to 29 per cent in the Assam Valley and the hills and plateaus of central India. The forests occupy 48.5 per cent in the eastern Himalayas, 52.5 per cent in the western Himalayas and 93 per cent in the Andaman and Nicobar Islands.

LAND USE BY RIVER BASINS

Another study of land use which is highly important is by river basins. This study was undertaken by the Irrigation Commission is 1972 and forms part of their Report. A summary of the land use and forest area by river basins in the different States is given in Table 2.6. It may be noted that the river basins 1-8 namely Chambal, Yamuna, Ramganga, Tons, Karamnasa, Gomti, Ghaghara, Son, Gandak, etc., all form part of the main Ganga river basin which constitutes almost 25 per cent of the land area of the country. Within these catchments, there is a very wide variation of percentage of forests.

The percentage of forests in some catchments like the Son and Barak is as high as 38 to 40 per cent. In the catchments of the Narmada, Mahanadi and Godavari the percentage of forests varies from 30 to 32 per cent. This figure is 18 to 20 per cent in the catchment of the Penner, Tons, Karamnasa and others, while in the Yamuna catchment this figure is 11 per cent. About the lowest percentage of forests is in the catchment of the Gomti river, being 6 per cent and only 2-3 per cent in that of the Gandak and the Luni. A close study of the land use, forest area and the condition of erosion in different catchments is basic to the development planning for these areas.

Forest area by ownership and legal categories

Table 2.7 shows forest area in India in the different states divided under the various legal classifications—reserved, protected and unclassed. These figures are based on the brochures issued by the Central Forestry Commission, Government of India. Out of the total forest area of 75 m ha, 52.1 per cent forests is reserved, about 31 per cent is protected, while 16.9 per cent is unclassed. Again out of the total forest area, 95.7 per cent is state owned. Of this an area of 69.56 m ha is controlled by Government forest departments, while the remaining 1.97 m ha are controlled by other Government depart-

Table 2.6: **Land use and forest area by river basins in India** (in '000 ha)

Sr. No.	Name of the River Basin	Geog. area	Reporting area	Area under forests	Area not available for cultivation	Uncultivated culturable area	Net area sown	Name of the States in which the basin lies
1	2	3	4	5	6	7	8	9
1.	Chambal	13,047	13,898	1,225	2,533	3,600	6,540	M.P., Rajasthan, U.P.
2.	Yamuna	22,675	22,309	2,575	2,939	3,726	13,051	H.P., Haryana, Punjab, U.P., Delhi, M.P., Rajasthan
3.	Ramganga	3,249	3,221	700	443	236	1,842	U.P.
4.	Tons, Karamnasa and others	2,857	2,833	516	420	417	1,480	M.P., U.P. & Bihar
5.	Gomati, Ghaghara and others	10,113	10,067	617	1,710	1,178	6,508	U.P. & Bihar
6.	Son	7,126	7,066	2,864	604	1,424	2,174	M.P., U.P. & Bihar
7.	Gandak and others	5,730	5,671	169	1,124	527	3,851	U.P., Bihar & W.B.
8.	Other Right Bank Tributaries of Ganga	9,710	9,643	1,603	1,311	2,066	4,663	Bihar & W.B.
9.	Main Ganga	10,733	10,629	1,953	1,798	941	5,937	U.P., Bihar & W.B.

10. Brahmaputra	18,711	18,711	2,237	4,228	9,388	2,758	Arunachal, Assam, Meghalaya, Nagaland, W.B.
11. Barak and Others	7,815	7,774	2,977	3,683	370	744	Manipur, Tripura, Assam (inc. Mizoram) Nagaland, Meghalaya
12. West flowing rivers between Kanyakumari and the Tapti	11,218	10,742	3,172	1,297	1,941	4,338	T.N., Kerala, Mysore, Goa, Maharashtra, Dadra & Nagar Haveli, Gujarat
13. Tapi (including the Kim)	6,514	6,363	1,647	424	492	3,800	M.P., Maharashtra & Gujarat
14. Narmada	9,880	9,867	3,167	799	1,402	4,499	M.P., Maharashtra & Gujarat
15. Mahi (incl. the Dhadhar)	3,484	3,412	481	721	684	1,598	M.P., Rajasthan & Gujarat
16. Sabarmati	2,167	2,077	213	316	284	1,264	Raj., Guj.
17. Luni and other rivers of Saurashtra & Kutch	32,185	31,678	794	7,437	9,288	14,159	Rajasthan, Gujarat & Diu
18. Indus	32,189	14,375	3,061	1,562	2,669	6,969	J & K

Table 2.6 (*Contd.*)

1	2	3	4	5	6	7	8	9
19.	Sabarnarekha and other east-flowing rivers between the Ganga and the Baitarani	2,920	2,916	610	408	606	1,292	Bihar, Orissa, W.B.
20.	Brahmani and the Baitarani	5,183	5,173	1,225	747	1,172	2,029	Bihar, M.P., & Orissa
21.	Mahanadi	14,159	13,971	4,500	1,477	2,370	5,624	M.P., Orissa, Bihar, Maharashtra
22.	East flowing rivers between Mahanadi and the Godavari	14,159	13,971	4,500	1,477	2,370	5,624	M.P., Orissa
23.	Godavari	31,281	30,784	9,119	2,734	4,496	14,435	A.P., M.P., Maharashtra, Mysore & Orissa
24.	Krishna	25,895	25,639	2,944	2,346	4,761	15,538	A.P., Maharashtra, & Mysore
25.	East flowing rivers between Krishna & Penner	2,467	2,458	374	461	532	1,091	A.P.
26.	Penner	5,521	5,470	1,118	815	1,456	2,081	A.P. & Karnataka

27. East flowing rivers between the Penner and the Cauvery	6,505	9,437	964	1,233	1,817	2,423	A.P., & Karnataka, T.N., Pondicherry
28. Cauvery	8,790	8,227	1,278	1,152	2,056	3,741	Kerala, Karnataka, T.N.
29. East flowing rivers between the Cauvery and the Kanyakumari	3,509	3,493	307	550	980	1,656	T.N.

Notes: I. Area not available for cultivation consists of (a) area under non-agricultural uses and (b) Barren and unculturable areas.

II. Uncultivated culturable area consists of
- (a) Permanent Pastures
- (b) Misc. tree crops and groves
- (c) Fallows.

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Table 2.7: State-wise forest area and its classification (in '000 ha)

States/Union Territories	Forest area (1981)	Legal classifications			Forest area under working plans	Utilisation status		
		Reserved	Protected	Unclassed		Forest area in use	Area potentially utilisable	Remaining forest area
Andhra Pradesh	6,357	4,974	1,237	146	6,437	3,111	1,661	1,665
Assam	3,071	1,707	—	1,363	1,650	2,687	165	229
Bihar	2,923	505	2,417	1	2,816	2,653	—	225
Gujarat	1,965	1,289	107	569	1,388	1,672	—	287
Haryana	170	23	143	4	120	12	30	104
Himachal Pradesh	2,114	183	1,713	—	1,556	975	202	1,000
Jammu & Kashmir	2,189	2,189	—	—	2,104	557	3	1,544
Karnataka	3,839	2,840	395	603	1,225	3,364	235	158
Kerala	1,125	934	—	191	854	725	172	236
Madhya Pradesh	15,541	8,100	6,908	534	12,291	10,182	4,009	2,048
Maharashtra	6,417	4,283	1,537	597	5,054	4,371	254	2,047
Manipur	1,515	138	417	961	39	291	311	—
Meghalaya	851	71	1	779	—	72	565	—
Nagaland	290	48	52	190	18	58	179	52

Orissa	5,996	2,504	3,491	1	2,182	5,683	1,042	68
Punjab	259	4	103	151	58	100	—	106
Rajasthan	3,044	1,197	1,508	340	3,461	1,397	1,215	849
Sikkim	282	224	58	—	282	—	107	175
Tamil Nadu	2,201	1,812	333	56	2,112	1,784	37	433
Tripura	592	386	206	—	226	357	48	198
Uttar Pradesh	5,115	3,465	13	1,637	4,054	2,473	599	2,003
West Bengal	1,183	700	426	57	711	1,080	65	38
Union Territories								
Andaman & Nicobar Island	714	291	423	—	479	502	243	39
Arunachal Pradesh	5,154	1,257	1	3,884	522	800	4,354	—
Dadar & Nagar Haveli	20	20	—	—	20	20	—	—
Delhi	—	—	—	—	—	3	—	1
Goa, Daman & Diu	131	4	—	127	—	76	30	25
Mizoram	1,663	631	165	867	—	56	469	188
Total	74,721	39,779	21,654	13,289	49,659	45,061	15,995	13,730

ments. A total area of 2 m ha is controlled by corporate bodies, while 1.20 m ha are under private ownership.

Table 2.7 also shows the forest area under Working Plans, as also the exploitable area (i.e., forests in use), besides the potentially exploitable and the non-exploitable area.

Population trends

The trends of human and animal population have a far-reaching effect on land use and forest position in any country. The human population of undivided India was estimated to be 150 m in 1850, while it rose to 315 m in 1901. The population was estimated to be 310 m in 1921 and rose to 389 m in 1941. After partition, India's population was 342 m in 1949, and doubled to 684 m in 1981. The 1981 Census has revealed that our population is still growing at an exponential rate of about 2.23 per cent. Population projections made by the Government of India, Planning Commission show (Table 2.8) that in 50 years from now we may have about 1,231 or 1,375 m people, depending upon the rate of growth in the coming years.

Table 2.8: Population projection

Year	Projected population Lower growth rate	Higher growth rate, m
1981	–	683.8 (actual)
2001	940.3	1,003.1
2031	1,231.7	1,375.4

Animal population

Animal population of undivided India in 1938-39 was 323.4 m. After partition, the animal population was 293 m in 1951. This rose by about 15 per cent to 336 m in 1961. During 1961-1972 the rate of growth of the animal population was only 5 per cent. The animal population during 1981 was assessed to be 342 m, consisting of 177 m cattle, 57 m buffaloes, 40 m sheep and 68 m goats.

CHAPTER 3

History of Forestry in India

Geological period

The earth is about 4,500 m years old. Fossil evidences show that the oldest living creature is hardly 1,600 m years old, the oldest fossil being of an algae. Fossil evidences also show that the first land plant in India appeared some time about 450 m years ago, and in the course of about 100 m years it evolved into various genus and species. The vegetation developed gradually. About 300 m years ago, the forests in India were gigantic, as confirmed by rich coal deposits in various parts of the country formed as a result of physico-chemical processes and abundant vegetation. Palaeo-botanical evidence testifies that Assam, Bengal and eastern part of Bihar were covered with dense forests more than 135 m years ago.

Tertiary forests of India saw the disappearance of gymnosperms and entry of angiosperms which developed into about 2,50,000 species. Apparently, the Himalayas were still under the seas in the Tertiary period when an arm of the sea extended right up to Jaisalmer and Bikaner in Rajasthan. Presence of lignite beds and coal seams in parts of India indicate that extensive forests existed during Tertiary period. Neyveli lignite beds near Cuddalore indicate the presence of marshy conditions 10 to 20 m years ago.

Advent of man and forests

It is believed that man appeared on the scene sometimes in the early middle period of the geological Pleistocene Age in the form of Apeman. The Apeman used wood as fuel. They could uproot small trees or tear off small branches by sheer physical strength but apparently had no means of cutting them down. The Palaeolithic and Mesolithic man of India suffered from similar disadvantages. But Neolithic man started cutting down bigger trees as these people were equipped with stone axis. These people started constructing houses and used wood for this purpose.

Aryans migrated to India between 2000 and 1000 B.C. from the West in batches. At that time, it is believed that people in this country were using stone, bronze and copper for different purposes but not iron. The Aryans introduced the use of iron for manufacture of agricultural equipments such as axes, hatchets, sickle, plough shares and various types of weapons. Aryans carried on almost a systematic deforestation in the present Punjab to meet the requirements of their settlements. They were mainly agriculturists but they were also pastoral. As the population increased, more forests were cleared. Aryans used wooden vehicles such as carts and chariots. Their villages consisted of thatched cottages. The doors, windows, posts, rafters, ridges and bottoms were entirely made of wood, which was obtained from the forests. The local population used to live inside forests at this time and were still using stone and copper. The forest dwellers were the descendants of the Proto Australoides who had come to this country and are represented at present by the Birhors, the Santals, the Bhils, the Juangs, the Korwars and the Mandas.

Forests in the Vedic period

The various *Vedas* written about 1500 B.C. describe the forests. It is believed that the Rishis had knowledge of poisonous and medicinal values of various trees, shrubs and herbs. A good deal of information about forests is available in the *Ramayana* and the *Mahabharata*. According to the *Mahabharata* account, Indraprastha was an afforested locality. According to *Vishnu Purana* and other scriptures, nine important forest regions were recognised in India even though their exact boundaries cannot be worked out.

According to the *Puranas*, trees not only give leaves, fruits, flowers, shade, roots, barks and timber but they also help ancestors to achieve heaven. Rishis have very early warned against deforestation and they advocated against cutting of trees because they thought that this would result in poor rainfall.

Forests in the Maurya period

Information about forests during this period is available from various sources. These are Kautilya's *Arthashastra* (321 B.C.), *Indika* of Megasthenes (305 B.C.), *Mudrarakshas* of Visakhadatta, inscriptions of Ashoka (273 B.C.—236 B.C.), etc.

In the administration of Chandra Gupta Maurya, there was a regular Forest Department administered by the *Kupyadhyaksha* (Superintendent of Forest Products). The *Kupyadhyaksha* used to be the Head of the Department and his maximum salary was 1,000 panas (silver coins). The *Kupyadhyaksha* was assisted by a number of *Vanapalas* or Forest Guards.

The duties of *Kupyadhyaksha* as specified in the *Arthashastra* were to increase the productivity of the forests, to sell trees after fixing their prices. classifying strong trees as *saka* (*Tectona grandis*), *arjuna (Terminalia arjuna*), *madhuka* (*Madhuca latifolia*), *sala (Shorea robusta*), *simsupa* (*Dalbergia sissoo*), *sarata* (*Pinus longifolia*), *aswakarna* (*Shorea robusta*), *Kasamura* (*Gmelina arborea*), *priyaka* (*Pterocarpus marsupium*), *kadira* (*Acacia catechu*), and *dhava* (*Anogeissus latifolia*), etc. These duties also included classification of different types of bamboos, canes, fibre plants and plants of which the leaves were used for writing material like *tala* (*Borassus spp*), *tali* (*Corypha umbraculifera*) and *bhujra* (*Betula utilis*). He was also responsible to classify all flowering trees, medicinal herbs and poisonous plants, and impose fines on all those who cut down trees in the forests without permission. He also collected poisonous snakes and other animals and kept them for sale.

The *Kupyadhyksha* also collected skins of dead animals to be found in the forests, and set up factories for the manufacture of articles which were needed for domestic or defence purposes, either inside or outside the city. The Mauryan empire was divided into five divisions each under a Governor. There was a forest factory attached with the headquarters of each division. The headquarters were at Patliputra (Patna), Takshasila (Taxila), Ujjaini (Ujjain), Tosali (Dhauli) and Savarngiri. *Arthashastra* mentions three classes of forests in the Mauryan Empire. These were:

1) Reserved forests,
2) Forests donated to eminent Brahmins, and
3) Forests for the public.

Reserved forests were of two categories, namely (a) reserved forest for the King and (b) reserved forest for the State. Forests for the Kings were mainly for shooting and pleasure. Forests for the State were meant for capture of elephants and supply of timber.

Forest in the Gupta period

Forests were one of the main sources of revenue in the Gupta period. There are records for the collection of forest revenue. Plantations of fruit trees were carried out in the forests. Forests were supplying timber, elephants, bamboos, canes, rope-making plants, medicinal herbs, etc.

Forests in the Muslim period

The Muslim rulers though fond of roadside trees, gardens and shooting were comparatively less interested in forest management. However, during the reign of the great Moghul Emperor Akbar different kinds of wood were weighed, and lighter and heavier woods were recognised as indicated in *Ain-i-Akbari*. Akbar, who evinced interest in the planting of trees along canals, directed that on both sides of the canal down to Hissar, trees of every description, both for shade and blossom, be planted so as to make it like the canal under the trees in Paradise.

Forests in early British period

The newly established British administration in India was initially not alive to the need for careful husbanding of forest resources, and was even under the impression that the forest wealth of India was inexhaustible. The British themselves were new to the ideas of systematic forestry, as they had no developed forest organisation then in Britain. As supplies of first class oak timber from other areas became short in England, large quantities of teak from India were used for the British Admiralty's fleet.

The first step in Indian forestry came in South India. In the year 1800, a Commission was appointed to enquire into the availability of teak in the Malabar forests. Regulations followed prohibiting the felling of teak below 52 cms in girth. In 1805 a Forest Committee was constituted to investigate into the capacity of forests and the status of proprietary rights in them. The Committee found that the more accessible forests had been overworked, and that more distant areas could be tapped only after the construction of roads at a high cost. As a consequence of this report, a proclamation was made by the East India Company declaring "Royalty" rights over teak trees in South India, and prohibiting unauthorised felling of teak. On November 10, 1806, the Government of Madras appointed Captain Watson of the Police as Conservator of Forests to organise the production of teak and other timber suitable for the navy for ship-building. Watson was thus the first person in India to be named the Conservator of Forests. However, Watson only established a timber monopoly throughout Malabar and Travancore. His methods gave rise to discontent, and in 1823 the post of the Conservator was abolished.

In 1842, Connolly, Collector of Malabar initiated action that resulted in the world-famous teak plantations of Nilambur. Initially the work was consolidated by the tireless efforts of his Assistant, Sub-Conservator Chathu Menon.

In 1847 Gibson was appointed, in addition to other duties as Conservator of Forests by the Government. In 1856 Cleghorn was appointed as the first regular Conservator of Forests in the Madras Presidency. In 1825, Wallich had been deputed to enquire into and report on the extensive forests at the foot of the Himalayas. His report pointed to the need for conserving the forests of *sal* and *sissoo* in Avadh and Tarai.

Captain Longden was deputed by Lord Dalhousie to explore and report on the forests of the Western Himalayan Range from Chamba eastwards, while in 1854, a Superintendent was also appointed for the forests in Dehra Dun and Rohilkhand.

In 1850 the British Association in Edinborough formed a Committee to consider the destruction of tropical forests in India. The Committee found that over a large portion of the Indian Empire, there was an almost uncontrolled destruction of the forests due to the careless habits of the population, while in the forests of Malabar (where the British rulers had exercised some supervision) improvements had already taken place, and these improvements might be extended to the forests over the rest of the country. The need for forming plantations in depleted areas was pointed out, as also the urgency for prohibiting the cutting down of immature growth, and the importance of reserving and maintaining forests in high altitudes and in areas of peculiar physical structure. The Committee also stated that indiscriminate clearance of forests around localities from where water supplies were derived was to be greatly deprecated. In 1854, Michael was appointed Superintendent of the Annamalai Forests in the South, after he had been trained in Burma to learn the methods of dealing in timber. Michael first recognised the advantage of using saw in place of the axe.

Charter of the Indian forests

In 1855 Lord Dalhousie, then Governor-General promulgated for the first time an outline for forest conservancy for the whole country by the issue of a Memorandum of the Government of India dated 3rd August, 1855. Stebbing rightly calls it as the "Charter of the Indian Forests". The Memorandum resulted from the reports submitted by McClelland, Superintendent of Forests in Burma (then part of the Indian Empire). In the year 1856, Brandis was appointed Superintendent of Forests in Pegu (Burma), and later came to serve in India. Brandis was a scientifically trained forester, having received his training in Germany, at that time the only fine training ground in forestry, besides Nancy in France. He also possessed other attributes which go to make a great scientific pioneer. His contributions as Inspector-General of Forests of India laid the sure foundation on which India's forestry developed so satisfactorily in the subsequent 100 years. In 1856 and in 1857, rules for the conservancy of trees in Rawalpindi and Hazara districts respectively were published, marking the commencement of protection of forests in Punjab.

The years 1857 and 1858 saw the Indian mutiny or the first war of Indian independence and the royal proclamation declaring Queen Victoria as the Empress of India. The mutiny brought out the want of facilities for rapid communication, and the tremendous impetus given to railway construction after the mutiny caused heavy demands on forests. While in the early period of British rule, timber extraction was mainly towards supplying the needs of the British Navy, the years following the Indian mutiny saw the exploitation of forests throughout the country for supplying quantities of railway sleepers and other material required for railway construction in different parts of the country.

In Madras, however, apart from continuing the work of raising teak plantations in Malabar, efforts also began for raising plantations in the Nilgiris. About 1858, exotic Acacia or wattle species was introduced in South India, and this resulted subsequently in its large-scale plantations in the Nilgiris. During the period 1858-64, plantation activity became a recognised part of forest conservancy.

In 1861, Cleghorn published. his book on *Forests and Gardens of South India.* In 1864 he was associated with Brandis in organising Forest Administration under the Government of India. In 1863 the necessity for early demarcation of the government and village forests in Madras was pointed out by Brandis and Cleghorn. In Bombay, the efforts were made in forest conservancy which began with the appointment of Gibson as Conservator of Forests. Gibson directed his energies to three main objects, viz., (i) prohibition of shifting cultivation, (ii) starting of thinnings in young teak areas and (iii) formation of teak plantations. In 1862, the Bombay Forest Department was recognised to provide for assistance to the Conservators in seven places; but the other forest establishments of the districts continued to be under the Collectors.

In the forests in the Central Provinces, large tracts remained unexplored for a long time. In 1861, the Government declared the Central Provinces to be a Chief Commissionership. Temple, the first Chief Commissioner, realised the importance of forests in the economy of the undeveloped Provinces, and Captain Pearson was appointed as the Superintendent of forests. The first forest areas with which Pearson dealt with a view to forest conservancy were in the Saugor and Nerbuda territories. He was assisted by Lt. Forsyth and Lt. Douglas. Forsyth wrote his book on *The Highlands of Central India*, giving a very vivid account of those forests as they were in those days. As a result of a joint inspection by Pearson and Brandis in 1863, it was decided that further forest conservancy work in the Central Provinces should concentrate on (i) demarcation of reserves, (ii) assessment of resources from which forest revenue might be raised, and (iii) protection of forests from fires. Within a year rules were drafted for the better management of the forests, and the attention of the Government was drawn to the need for prohibition of *Dhaya* or shifting cultivation at least in valuable forest areas.

In the North-West Province and Avadh, attempts at forest protection were made only in the middle of the 19th century, when Commissioners were appointed as ex-officio Conservators of Forests. In 1860 Ramsey who was the Commissioner of Kumaon and Garhwal took energetic steps for conservation of forests in the Hill Districts. Brandis visited Bengal, Avadh; the North-West Province and the Central Province. Then followed the appointment of Webber as Forest Surveyor in the North-West Province. In 1868 a Forest Department with its own Conservators was inaugurated in the North-West Province. Webber's book *The Forests of Upper India* gives descriptive accounts of his marches and sporting anecdotes. In the Lower Provinces of Bengal and Assam, attention was paid to forest conservation only in 1862. In 1864 Anderson was appointed Conservator of Forests of the Lower Provinces, in addition to his duties as Superintendent of the Botanical Gardens in Calcutta.

Establishment of forest departments under Government of India

The Governor-General in his letter dated 1st November 1864 to the Secretary of State for India pointed out that the idea of allowing proprietary rights in forests to individuals must be abolished, as such rights might lead to the destruction of forests. It was considered necessary that all Government forests should be strictly set apart and made inalienable. It was however conceded that provisions would have to be made for the continued exercise of certain private rights already existing, but it was suggested that even those rights should be abolished on equitable terms wherever possible. In his letter, the Governor-General stressed the need for: (i) exercising great care in the disposal of wastelands containing forests, (ii) demarcating and fixing the limits of forests to be preserved as such, and (iii) enacting a comprehensive Indian Forest Act. It was suggested that an Officer should be appointed solely in charge of forest matters in order to carry out an all-India policy. As a sequel to this, an Inspector-General of Forests working directly under the orders of the Government of India was appointed. He was entrusted with the duties of advising the Government on all questions concerned with forest administration and introducing a thorough system of management and conservation throughout all the forests in the territories under the Government of India. The Inspector-General was not invested with any power of direct control over the forest management under the Local Governments, who were issued instructions directly on such matters by the Government of India. Exchange of correspondence between the Governor-General and the Secretary of State resulted in the birth of a separate Forest Department under the Government of India, and Brandis became the head of this Department. Under the guidance of Brandis as India's First Inspector-General of Forests, the Forest Service proceeded to transform the working of India's forests—from the initial practice of exploiting them merely for obtaining supplies of timber, to one of treating them as a biological growing entity of much value, and handling them in accordance with the principles of scientific forestry.

Beginnings of forest organisations

As soon as Brandis was appointed Inspector-General of Forests, Cleghorn was deputed to assist him. The Indian Forest Act of 1865 came into being as the first attempt at forest legislation by the British in India. Under this Act, the local Governments were empowered to draft local rules for enforcement in their respective regions. Steps were accordingly taken to prevent acts which caused injury or destruction to the forests. Though some of the local Governments lagged behind in the application of the Indian Forest Act to their territories, all the areas under British rule had either extended the Indian Forest Act to their territory or brought out special Acts by 1882.

Brandis took steps to recruit trained personnel for controlling the work and the establishments of the Forest Department. In 1869 there was a reorganisation of the Forest Service. Brandis also took steps for affording Forest Probationers training at forestry centres in Europe. He first selected two gentlemen already trained in forest management in Germany for service in India. They were Schlich, who became a world renowned forester, and Ribbentrop, who succeeded Brandis as Inspector-General of Forests. Schlich and Ribbentrop arrived in Calcutta on 16th Feb., 1967. Brandis's proposal in the matter of technical education for forest officers consisted of (i) providing facilities for officers already in the forest department in India to receive further scientific training in forestry in Europe, and (ii) selection of young men in Europe for training in the continent before they joined the Indian Forest Department. Brandis also outlined proposals for the appointment of Forest Rangers.

About 1863, Beddome, then Conservator in Madras, produced the first *Manual of Forest Operations*, almost a regularly drawn working plan. During the period 1865-70, the planting of Casuarina in the coastal areas of Madras was initiated to make good the large quantities of fuel removed from the existing forests to meet the needs of the railways. The large scale demand of fuel for the railways resulted in the Government agreeing to large tracts of wastelands being converted into fuel reserves and their being placed under the Forest Department. The period 1865-70 also marked the first attempt at fire protection as a measure of forest conservancy in the Bori Reserve in Central Province. Stewart, Punjab's first regular Conservator of Forests (1864), carried out detailed enquiries regarding fuel supplies required for the railways in that region. Sleepers also continued to be supplied from the timber forests in the hills of the Punjab. As the first attempts at raising *deodar* plantations were not successful, Stewart examined the question in detail and considered that it should be the duty of the Department rather to conserve the existing resources than to raise new plantations of *deodar* in the Western Himalayas. He considered that the best course would be in felling 'first class' trees, not exceeding 1/3 of the whole stock, in such a manner as to leave convenient space for the growth of the young trees obtained by natural sowing from the remaining two-thirds of mature trees. It would thus be seen that Stewart visualised the gradual introduction of 'shelterwood systems', which were later so successfully developed in Punjab.

In the North-Western Province, forest conservancy continued in the hands of Commissioners until in 1868 Pearson, the first Conservator of Forests in the Central Province, was transferred as its first Conservator to the North-Western Province. The appointment of Pearson helped in rectifying matters. During the period 1865-70 large quantities of timber were made available from the North-Western Province. In Avadh forests, which were under the management of Reid, who was appointed as Conservator of Forests, forest conservancy was introduced on systematic lines as a result of a series of valuation surveys by Brandis, and cultural operations were undertaken in reserved forests. The general inspection of Assam forests began in 1868, when Mann examined the forests of the districts of Lakhimpur, Sibsagar, Nowgong, Naga Hills and Khasi and Jaintia Hills.

Organisation of forests

By 1870 the foundations of the Forest Department may be said to have been well and truly laid by Brandis. A regular forestry service began to exist and definite progress in forestry was shown. During the period 1871-1900, preparation of Working Plans commenced. Treatments of the forests were prescribed on scientific considerations. In the early years of the Forest Service, the main task of the forest officers had been the exploration of the forests under their charge. Then came the arduous task of demarcation of the forests.

Forest Acts

A revised Indian Forest Act (Act VII of 1878) was passed in the year 1878, and it extended to all Provinces of British India with the exception of Madras, Coorg, Burma, Bihar, the Hissar district of the Punjab, Ajmer and Baluchistan. This Act aimed at improving on the inadequacies of the Indian Forest Act of 1865. The Revised Act provided for the constitution of reserved and protected forests. In 1882 the Madras Forest Act was passed. During the last two decades of the nineteenth century, some of the forest areas of the country were constituted either into reserved forests or protected forests. During this period (1880-1900) forest settlement was actively in progress in the various Provinces. Ribbentrop's book *Forestry in British India* gives an account of the hard work which was turned out during the period in regard to various settlements, demarcation and survey. In1885 forest training commenced at Cooper's Hill in England, as difficulty was experienced in training of Probationers in the continent. In 1878, a forest school was inaugurated at Dehra Dun which turned out Forest Rangers for all the Provinces. A Provincial Forest Service was inaugurated in 1891 to recruit in India itself suitable persons to work as Forest Officers. In the last decade of the 19th century considerable progress was made in Forest administration. A good deal of work went into construction of buildings and development of communications and some plantations were also formed in the period, besides natural regeneration.

Forest Policy of 1894

After the forests entrusted to the care of the Forest Department had been demarcated and surveyed, it was felt necessary to lay down certain principles on which the forests were to be managed. At this stage the Government of India invited Dr. Voelcker to examine the conditions of agriculture in the country and suggest how it could be improved. Dr. Voelcker submitted his report on *Improvement of Indian Agriculture* in 1893. Chapter VIII of this great report discusses the conditions of the forests and stresses the need of formulating a Forest Policy, with a definite bias for serving the agricultural interests directly. On the basis of his recommendations, the Government of India issued Resolution No. 22F, dated 19th October, 1894, declaring its forest policy which is a landmark in the history of forestry management in India.

The Government of India were guided by the following:

1) The sole object to which the management of forests is to be directed is to promote the general well-being of the country.

2) The maintenance of adequate forests is dictated primarily for the preservation of the climatic and physical conditions of the country and, secondly, to fulfil the needs of the people.

Subject to these conditions,

a) Permanent cultivation should come before forestry.

b) The satisfaction of the needs of the local population at non-competitive rates, if not free, should over-ride all considerations of revenue.

c) After the fulfilment of the above conditions, the realisation of maximum revenue should be the guiding factor.

The Government-owned forests were classified with reference to their primary functions as follows:

i) Forests, the preservation of which was essential on climatic or physical grounds,

ii) Forests that afforded a supply of valuable timbers for commercial purposes,

iii) Minor forests, and

iv) Pasture lands.

The above classification was not intended to be rigid and a particular forest might fulfil more than one function.

Progress of forestry in 1900-1947

There was a good alround progress in the different fields of forestry during the period from 1900 to 1925. In 1906 the Imperial Forest Research Institute was established with six officers—the Silviculturist, Superintendent of Forest Working Plans, Forest Zoologist, Forest Botanist, Forest Chemist and Forest Economist. In 1914 the main building of the Forest Research Institute was opened by Lord Curzon at Chandwa, Dehra Dun.

During the World War I many of the younger officers of the Forest Department were called up to serve in the army, and this put additional work on the officers left in the Department, specially as they had to deal with large demands for timber and other forest produce. Timbers from India's forests were utilised in various mid-Eastern fields of World War I. The Forest Research Institute at Dehra Dun also carried out important investigations on the possibilities of utilising various woods.

In 1901 a separate North-Western Frontier Province was formed, the North-Western Province was renamed as the Agra Province and the United Province of Agra and Avadh came into being. In 1911 a composite Bihar and Orissa Province was formed. The importance of preparing Forest Working Plans on scientific basis was recognised by the various forest administrations. In 1905 the idea of having a Chief Conservator of Forests in each Province crystallised, though appointments of Chief Conservators of Forests began only from 1907. By 1921 the only Provinces without a Chief Conservator of Forests were Bihar and Orissa, Bengal and Assam. In 1910 a Board of

Forestry composed of representative Conservators under the Presidentship of the Inspector General of Forests was set up which met once in three years to discuss the forestry programme.

As a result of the recommendations of the Royal Commission on Decentralisation (1909), it was felt that the Inspector General of Forests need not advise on every Working Plan, except where his views were specially asked for by the local Government. Separate Working Plan Circles in the charge of a Conservator came into existence. In 1912 the Madras Forest College was started at Coimbatore for training Forest Rangers for South India.

As a result of the movement for Indian Home Rule in 1916 and the Non-Cooperation Movement that followed, there was a general defiance against forest laws and damage to forests was caused by fires in some places (Bengal, Kumaon Hills of Uttar Pradesh, Orissa and Andhra).

In the political changes in 1921, 'forests' became a 'transferred' subject, and the administration of forests came to vest in the Government of the Province concerned. A course for training officers for the Indian Forest Service was commenced in Dehra Dun from October 1926. The all-India list for promotions to the rank of Conservators and Chief Conservators came to an end in 1935. Recruitment and training for the Provincial Forest Service ceased in 1926.

Afforestation works taken up in Punjab (Hoshiarpur) and Uttar Pradesh (Etawah, Terai and Bhabar) for reclamation of Chos, ravines and other eroded areas during the earlier period were continued during the period 1926 to 1927. Major silvicultural problems like the natural regeneration of deodar in the Western Himalayas, the artificial regeneration of teak in South India and the natural regeneration of *sal* received special attention. In the late 20s, interest first began in wild-life conservation. Indianisation of the Indian Forest Service came in 1922, whereby 40 per cent of the vacancies were reserved for Indians. With the coming in of the Government of India Act 1935, forests became entirely the concern of the Provinces. The Government of India and the Inspector General of Forests were to concern themselves only with the common or general aspects of forestry, namely, research and education, etc.

In 1926, the Forest Research Institute began moving into a vast estate of its own in New Forest just outside the city of Dehra Dun. Much credit goes to Sir Peter Clutterbuck, the then Inspector General of Forests for opening the new buildings and re-organising research in a major way. The research branches and sections were greatly expanded.

In World War II (1939-1945) enormous quantities of timber of many different species were supplied causing excessive fellings and advance working in almost all forest divisions in the Provinces. There were also extensive over-fellings in private forests of the Princely States. Many varieties of timber which had not been used previously in any appreciable quantity began to be consumed in large quantities.

Towards the end of World War II, Herbert Howard as Inspector General of Forests prepared a detailed report on Post-War Forest Policy in India mainly to rehabilitate the over-worked forests and improve future workings.

During the years 1925-1947 India made very rapid progress in organised forestry, excellent Working Plans were made and Forest Research made substantial progress. At the time of partition of India it can be safely said that India was leading in tropical forestry, and was not far behind in temperate forestry compared to the leading countries in the world.

Forestry in India—1947 to 1984

With the attainment of independence on 15th August, 1947. by far all the British Officers, who had done much to the cause of Indian forestry, left India and the Indian Officers assumed charge, as in other fields of Government, of the forest administration in all the spheres at the Centre and in the Provinces.

Further political changes took place. The Princely States, large and small, were either constituted into States of India or merged into the adjoining Provinces. Some of the large States like Travancore, Mysore, Hyderabad and Jammu and Kashmir had reasonably well-organised Forest Departments. Others like Bhopal and States in the Central and Eastern Indian State Agencies had benefited by advice from trained forest officers from the neighbouring British Provinces, and their forests were in a state of reasonable management. But the forests of other Princely States had served mainly as sources of revenue and little or no measures of forest conservancy had been practised in them. Such forests thus began to have the benefit of regular Forest Administration for the first time on the same lines as the British had developed in the forests under their control. There were also very considerable variations in the forest laws, forest organisations and forest working in the different units which now form the States of India. The task of consolidation of the forests, unification of forest laws as well as of extension of scientific management on a reasonably uniform basis became a major preoccupation for the Forest Departments.

Control of private forests

With the abolition of zamindari practically in all States of India, large areas of private forests were vested in the Government. A major work of the Forest Services in the early 1950s thus came about to be the control, organisation and management of the erstwhile private forests. By virtue of the foresight of the State Governments and the Forest Service, extensive private forests thus came under regular management which would otherwise have been lost. This happened specially in Bihar, Orissa, Madhya Pradesh, Uttar Pradesh and other States.

1952 National Forest Policy

In 1952, by virtue of the brilliant work done by M.D. Chaturvedi, the first Indian Inspector General of Forests, the Government of India enunciated a new National Forest Policy, enlarging on the earlier Forest Policy of 1894 and making good the omissions noticed in it. This policy will be considered elsewhere in this book (Chapter 14).

Reorganisation of States

Major political changes took place in November 1956, when the country's sub-divisions were re-oriented on a linguistic basis and 14 different States came into existence, each covering a major linguistic area. With this change the old Presidencies, Provinces and large Princely States like Hyderabad and Mysore lost their original shape and significance, and the political map of India assumed a new look. This resulted in considerable reorganisation of Forest Departments also. In 1959, the Madras Forest Department celebrated its first centenary of regular forest management and paid tribute to Cleghorn, its first Conservator of Forests. In 1961, the Centenary of Forest Administration for the country was celebrated at Dehra Dun in a befitting way. The last Member of the Indian Forest Service retired in 1962.

Reconstitution of the Indian Forest Service

An event of major importance happened in 1966 when after special Parliamentary legislation, the Indian Forest Service was freshly constituted and initial recruitment/selection took place for the Indian Forest Service from the existing State Forest Services. This was an important land-mark in the history of post-independence forestry, and gave considerable moral boost as well as reasonable opportunities for the serving forest officers, even though the emoluments and status left a good deal to be desired. Over the course of years, a major expansion of the forest service has taken place to cope with the increased responsibilities of work, and the pace of development programmes particularly under the Five Year Plans.

Reports of National Commission on Agriculture

Another important event affecting forestry in recent years was the appointment of the National Commission on Agriculture in August 1970. The Government resolution setting up the Commission specifically referred to forestry as one of the items for study and report by the Commission, and includes as parts of Terms of Reference as follows:

> Development of forestry, including farm forestry as a factor in agricultural progress and as a source of raw material for industry, export as well as for sustaining the ecological balance in nature, and for providing employment opportunities to large sections of tribal and other population living in these areas.

The Report of the Commission was presented in January 1976 and included a full volume on forestry. Before publication of the final report the Commission also issued interim reports as follows:

1) Man-made Forests—Production Forestry
2) Social Forestry
3) Forest Research and Education

The Report of the Commission including the Interim Reports are documents of considerable significance in Indian forestry.

CHAPTER 4

Ecology of Indian Forests

Introduction

To understand the forests of India, it is necessary to know the various forests in which the Indian vegetation may be classified. A forest type may be defined as a unit of vegetation which possesses broad characteristics in physiognomy and structure, sufficiently pronounced to permit of its categorisation from other such units. Obviously, in the first place this does not take into account the edaphic or biotic factors. The 'forest types' are directly connected with the practice of scientific forestry, and indeed their practical utility, is the main justification for distinguishing them.

Units which are associated with a definite site factor and differ appreciably from the existing type of the surrounding area are called 'edaphic' types. It may be mentioned that in the large majority of cases, specially those of a climax status, there are no sharp boundaries between adjoining types. There is usually a transition zone or ecotone which may be of any extent, and sometimes quite extensive.

The ecologists' fundamental unit for plant communities, the 'association' has been defined as "the largest floristic unit consisting of a definite assemblage of species (usually with definite dominants) and a definite habitat and as being characterised by its definite floristic composition, life form, structure and habitat." This is one definition; however, another definition described the association as a community of definite floristic composition within a formation—which latter has been defined on physiognomy, not on floristics. The associations of temperate forests tend to be dominated by a few or only one species or consociations, whereas tropical forests with their richer flora specially in the more luxuriant moisture types have mixed associations with many dominants, seemingly equally adapted to the site.

Basis of classification

There are eight possible basis for classification of vegetation, as follows:

1) *Physiognomy*: It provides an easy basis for a rough differentiation of very broad categories and has been used to some extent by most writers including Schimper. Ordinarily it includes characteristics such as evergreen or deciduous nature and such features as are connected with very dry or very wet sites.

2) *Structure*: It covers stratification, dimensions, especially height and spacing. Fosberg uses spacing as its starting point followed by height. Richards gives importance to the number of strata.

3) *Function*: It covers the common morphological characters of the species, some being related to site conditions (Raunkiaer). Buttressing, bark-form, leaf-size and cauliflori provide examples for this. Along with structure this criterion is widely used by foresters.

4) *Floristics:* The taxonomists prefer this basis as the most objective. However, this presents difficulties of identification and obscures the relation between vegetation of varying floristic areas.

5) *Dynamics*: Most vegetational types are always changing even if slowly. The use of this criterion involves the application of some part of the Clementian theory (1916) of plant succession and vegetation climax.

6) *Habitat:* While climate and soil moisture factors are essential parts of all classifications, none has been yet put forward based solely on habitat factors. It would also appear unrealistic to put up a classification based only on factors other than those of the vegetation itself.

7) *Physiography:* This factor is obviously important in the occurrence and distribution of forest types. For example, a steep southern slope and a gentle northern slope both at the

same altitude will determine the presence of different forest types associated with corresponding climatic differences.

8) *History*: While the history of a site and vegetation therein are often very important in determining its present condition and should always be found out as far as possible, it is usually conjectural and as such is not admissible for objective classification.

Factors determining forest types

The type of vegetation met within a given locality depends on the climate, the soil and the past treatment. A careful study of these aspects is altogether essential for an understanding of the variation and the interrelationship of forest types.

Climate in relation to forest types

Temperature is the most obvious factor of climate. It can be broadly related to latitude, giving a rough differentiation into four zones:

a) Tropical -- very hot and winterless,

b) Subtropical—hot with a cool winter,

c) Temperate—a warm summer with a pronounced winter, and

d) Arctic—with a short summer and long severe winter.

Apart from latitude, the distribution of land and sea, altitude, prevailing winds and ocean currents are important, besides taking into account temperature ranges over the year. For India, the mean annual temperature exceeds 24°C over the whole country with the exception of the hill areas and the extreme North-West. On the basis of temperature, India may be divided into following four regions:

Table 4.1: Four temperature-wise divisions of India

Zone	Mean annual temperature	Mean January temperature	Winter
I Tropical	over 24°C	Over 18°C	None: no frost
II Sub-tropical	17° to 24°C	10° to 18°C	Definite but not severe; frost rare
III Temperate	7° to 17°C	—1° to 10°C	Pronounced, with frost and some snow
IV Alpine	Under 7°C	Under —1°C	Severe with much snow

Rainfall

India exhibits an extremely wide range of rainfall conditions, from less than 150 mm in the Thar desert to nearly 5,000 mm locally in the Khasi hills of Assam. Precipitation over 2,500 mm is met within three different parts of the country, namely the Western Ghats, North Bengal and Assam and locally in the Western Himalayas, e.g. Dharamsala. Besides total annual rainfall, its seasonal distribution has a far-reaching influence on vegetation. Except in the inner parts of the Himalayas and the North-West corner of the country, where rains and winter snow contribute an important part of the total fall, practically the whole rainfall in India occurs during the summer-autumn monsoon period. However, the rainy season varies in duration with a general increase from North-West to East and South-East so that upper Assam gets the shortest dry period and the North-West the longest.

Evaporation

For plant life, available moisture is of critical importance. Evaporation is regulated mainly by temperature and the relative humidity of the atmosphere and is also affected by the rate of air movement. Some authors have developed a new approach by paying more attention to the role of moisture stored in the soil and the energy relations involved in both evaporation and transpiration, now commonly called evapotranspiration. Potential evapotranspiration (p.e.) is the value that would be attained from a vegetation covered surface if moisture remained in adequate supply.

Obviously over most of the tropical India, the length expressed in months of dry seasons is vital for the vegetation of the area. Proximity to the sea acts both as a moderator of temperature and as a humidifier of the atmosphere and has a major effect on the climate and vegetation of the land so situated. Mountain masses largely create their own climates.

Gregarious tree species

It is essential to know some important ecological facts. The top canopy of many of our forests consists largely of single tree species. As examples may be quoted the chir pine forests besides blue-pine, deodar and spruce, while *sal* has its gregarious habit among the broad leaved trees, though it usually has some admixture of other species. The gregarious habit is also some times well developed in the underwood, as with bamboos or among the ground shrubs such as *Strobilanthes* species, *Clerodendron* and *Adhatoda*.

Human activities in general tend to increase the predominance of gregarious species. This may be done intentionally as in case of economically important species or unintentionally as by burning, in many *sal*, and chir pine forests.

The more luxuriant the growth, the more complex is the mixture. In wet tropical forests no single species contributes even 10 per cent. In fact, few species may be over one per cent of trees over 30 cms in diameter in such forests. In the tropical deciduous forests which occupy extensive areas in India, the greater part of the top canopy is formed by varying mixture of six to ten species.

Competition between species

Where a number of tree species grow together, there is acute competition between them for the limited amount of space, light, moisture and nutrients available on the site. As the trees grow larger there is room for fewer and fewer of them and the weaker either drop out altogether or at least lose their space in the top canopy. The first requirement for success is rapid height growth and the trees which reach higher, shade the slower growing ones and thus reduce the quantity of light the latter receive. If the species has a vigorous branching habit it can make fuller use of the advantage given by its height. It develops a leafy crown to help it to put on good diameter growth and thus suppress other competitors. Ability to endure shade is another important factor in seedling competition. The best combination is large seed with ample food supply to give the seedling a good start, fairly rapid height growth and then pronounced power of shade endurance.

Yet another factor is the variation in hardiness. As the young tree is exposed to many risks of damage from climatic factors, animals, parasitic plants and man, its power of resistance to these are important to a degree depending on the severity of their incidence. Resistance to fire is most important over extensive areas exposed to fire. Many *sal* forests owe their existence to the remarkable power of this species to withstand repeated burning and to establish itself on burnt grasslands, Exceptional fire resistance also largely accounts for the purity of chir pine forests and their occurrence in areas where under protection oak, blue-pine and deodar rapidly establish themselves. Fire resistant bark is essential to survive in many cases. An outer corky layer which will char without igniting is usually present, but some species are effectively protected by a thick smooth and sappy bark. As the fire usually sparks in a few minutes, low heat conductivity is important and lack of it can cause extensive death in trees.

Tropical wet evergreen forests are exceptionally sensitive to fires and have been eliminated by it from large areas in South India in favour of the more resistant species.

Grazing lands

After fire, grazing is the most important factor controlling the composition of the forests over most of the country excepting the wet tropical areas. Closely connected with grazing is lopping for fodder and fuel and other injuries left by graziers. Grazing leads to the replacement of woody undergrowth by more inflammable grass and a generally drier type of vegetation. It increases the chances that fire will be set intentionally or carelessly. In an already grassy area, however, grazing reduces the damage by reducing the grasses. Resistance to destruction by grazing is affected in plants by non-palatability due to tannin content as in teak, to acrid juices as in *Rhus*, to thorns as in *Acacias* or to sour smell as in *Holarrhena*. In long and heavily grazed areas it will be found that practically every tree is unpalatable, thorny or has good coppicing power and most surviving trees have more than one of these properties, all other species being eliminated. Heavy grazing also results in compacted surface soil in which germination becomes thin. Grazing thus results in a marked reduction in number of species; moderate grazing may, however, be helpful in some cases.

The degree of adaptability of species to the factors of the locality in which it occurs varies widely, and within limits the closer its adaption the more favoured is the species in its competition with others. For example, chir pine flourishes over a very wide range of altitude, rock and soil, only requiring good drainage.

The normal life span of a tree also influences species competition, a longer-lived species being at a considerable advantage. Abundant production of fertile seeds with a good dispersal mechanism greatly helps a species to gain ground against its competitors.

Succession and climax

In India new sites become available for colonisation by vegetation on the following:

1) New alluvial deposits—sands, gravels and silts
2) New estuarine deposits—clays and silts
3) Sand dunes
4) Landslips and
5) Screes.

Of these, the first may be almost devoid of humus. The colonisation of various sites by tree growth is fairly rapid under our climatic conditions. The coastal sands are mainly colonised by wind-borne seeds of casuarina. The original colonists of new sites are rarely found to regenerate on these sites. An important characteristic of colonising species is the presence of root nodules with nitrogen fixing bacteria, particularly important in sterile sands. These nodules occur specially in the leguminous species like *sissoo* and *Acacias*.

Primary succession

The vegetation first established on a new site is gradually replaced by new forms which in turn give way to others, until finally a stage is reached at which the vegetation is in equilibrium with the climatic and soil site factors, and further change apparently ceases when the type as a whole is considered. This progression in time is called the primary succession and the final stage is the climax vegetation. The early colonists start building up a true soil, adding humus by their leaf fall and roots and nitrogen from their root nodules. They also shade the soil and thus help establishing undergrowth. In the Gangetic alluvium in Uttar Pradesh the five following stages may be differentiated in succession:

1) *Acacia catechu—Dalbergia sissoo*

2) *Acacia catechu—Holoptelea—Adina—Albizzia procera*
3) *Holoptelea—Adina—Lagerstroemia parviflora—Salmalia—Terminalia bellerica*
4) *Adina—Lagerstroemia parviflora—Terminalias—Shorea*
5) *Shorea—Lagerstroemia—Terminalias—Adina*

A stable state or climax should ultimately be attained by the forests as well as by the soil supporting it, the composition and structure of both being maintained indefinitely. With the attainment of the climax the process of primary succession comes to an end. This is called the mono-climax theory. However, climax may not be identical in all cases over a climatically uniform area depending on variations in site conditions, thus developing separate recognisable climaxes. This is called poly-climax theory. The chief factors responsible for variation within the climax are micro-climate and soil and moisture relations. This leads one to think that at least a dynamic rather than a static equilibrium may be reached possibly with cyclic alterations of varying complexity. On the other hand the forests might be considered to be a cyclic continuum in which the parts are in an unstable equilibrium, leading to a theory of vegetation gradients and climax patterns. The climax would then be viewed as an average or most probable population.

In practice it is convenient to recognise various climax types. While the general climax is known as the climatic climax, the climax apparently dependent on soil peculiarities is an edaphic climax. Exceptionally poor sites particularly with low available moisture supplies often carry a type which is more xerophytic than corresponding to the general climate which is called pre-climax. Under the opposite conditions of locally cooler or moister sites, a more mesophytic type is found called post-climax. A type which is prevented from progressing to the climax due to biotic or other factors is termed as a sub-climax.

Retrogression

When adverse influences such as grazing, burning or felling enter into the picture in any forest, the progression is altered to a more or less marked retrogression to forms resembling those prevalent at an earlier stage. Sinking of the water table may produce the same results as appears to be happening in some of the sal forests of Uttar Pradesh.

Forest types of India

Adopting the classification of Champion and Seth (1968) the following 16 important forest types of India may be identified:

Major Groups	Type Groups	Characteristics
I Tropical forests	1. Wet evergreen forests	Dense tall forests entirely evergreen or nearly so
	2. Semi-evergreen forests	Dominants include deciduous species but evergreens predominate
	3. Moist deciduous forests	Dominants mainly deciduous, but some dominants and lower storey largely evergreen. Top canopy rarely dense and even but over 25 metres high
	4. Littoral and swamp forests	Mainly evergreen, of varying density and height but always associated, predominantly with wetness
	5. Dry deciduous forests	Entirely deciduous or nearly so. Top canopy rather light and rarely over 25 metres height, usually 8-20 metres
	6. Thorn forests	Deciduous with low thorny trees and xerophytes predominantly. Canopy more or less broken. Height under 10 metres

	7. Dry evergreen forests	Hard leaved evergreen trees predominate, with some deciduous emergents, often dense but under 20 metres height
II Montane sub-tropical forests	1. Sub-tropical broad leaved hill forests	Broad leaved largely evergreen high forests
	2. Sub-tropical pine forests	Pine association predominates
	3. Sub-tropical dry evergreen forests	Low xerophytic forests and scrubs
III Montane temperate forests	1. Montane wet temperate forests	Evergreen forests without conifers
	2. Himalayan moist temperate forests	Evergreen forests mainly selerophyllus oaks and coniferous
	3. Himalayan dry temperate forests	Open coniferous forests with sparse xerophytic undergrowth
IV Sub-alpine forests	1. Sub-alpine forests	Stunted deciduous or evergreen forests usually in close formation with or without conifers
V Alpine scrub	1. Moist alpine scrub	Low but often dense scrub
	2. Dry alpine scrub	Xerophytic scrubs in open formation

The above types have further been sub-divided into smaller groups, besides being divided into Northern and Southern subtypes.

Table 4.2 shows the forest area in India by main forest types and by States and Union Territories, as worked out by the Forest Research Institute, Dehra Dun. The last three types, viz., sub-alpine, moist alpine and dry alpine have been grouped together in the table. It is worth noting that these area figures are based only on considerations of climate and topography. and do not take into account the actual rock, soil, biotic factors and the actual vegetation. Even then the information is important.

It would be seen that by far, bulk of the forest area falls among the tropical dry deciduous and tropical moist deciduous types, these being about 29 and 23 m ha respectively. Thereafter, come the tropical thorn forests, tropical wet evergreen and sub-tropical pine forests, being 5.2, 4.5 and 3.7 m ha respectively under these three categories. The area under the tropical semi-evergreen type is 1.8 m ha, while the Himalayan moist temperate, and sub-alpine and alpine forests account for 2.7 and 1.8 m ha respectively.

The factual position of area under different forest types as existing at present and from time to time is not known, and needs to be determined, based on actual forest stock maps and aerial photographs. This should be a priority job for State and Central Working Plan Organisations and Forest Survey of India according to a time-bound schedule.

SUB-GROUP 1A—SOUTHERN TROPICAL WET EVERGREEN FORESTS

These occur extensively in Western Ghats from Bombay southwards, and are distributed in Maharashtra, Karnataka, Tamil Nadu and Kerala. They are also found in the Andaman and Nicobar Islands. The annual rainfall varies from 150 to 300 cm. The top canopy consists of *Dipterocarpus*, *Artocarpus*, *Hopea*, *Calophyllum*, *Dysoxylum* and other species. The second storey trees are *Palaquium*, *Hydnocarpus*, *Cyclostemon Diospyros*, *Elaeocarpus Syzygium*, etc., spp. Epiphytes, especially aroides, ferns, mosses, and orchids are numerous. The trees are often buttressed. Grasses are generally absent.

Table 4.2: **Forest area under different forest types by States and Union Territories** (Area: '000 ha)

Sr. No.	States/Union Territories	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	Total
1.	Andhra Pradesh	—	—	3,012	169	1,678	1,759	—	—	—	—	—	—	—	—	6,651
2.	Assam (including Meghalaya and Mizoram)	1,190	300	2,906	—	—	—	—	103	66	—	—	—	—	—	4,565
3.	Bihar	—	—	292	—	2,793	—	—	—	—	—	—	—	—	—	3,085
4.	Gujarat	—	—	356	48	1,406	130	—	—	—	—	—	—	—	—	1,940
5.	Haryana	—	—	—	—	80	31	—	—	25	—	—	—	—	—	136
6.	Himachal Pradesh	—	—	—	10	1,208	—	—	—	729	102	—	753	119	301	3,222
7.	Jammu & Kashmir	—	—	—	—	83	—	—	—	281	71	—	917	141	588	2,081
8.	Kerala	548	260	223	—	—	—	—	7	—	—	3	—	—	—	1,041
9.	Madhya Pradesh	—	—	7,258	—	9,757	266	—	18	—	—	—	—	—	—	17,299
10.	Maharashtra	—	358	1,073	—	4,218	1,025	—	12	—	—	—	—	—	—	6,686
11.	Manipur	190	—	272	—	—	—	—	—	135	—	5	—	—	—	602
12.	Karnataka	601	585	829	—	406	1,099	—	—	—	—	—	—	—	—	3,520
13.	Nagaland	82	45	23	—	—	—	—	—	87	—	73	—	—	—	310
14.	Orissa	—	284	4,487	113	818	—	—	114	—	—	—	—	—	—	6,816
1.5	Punjab	—	—	—	—	136	26	—	—	17	—	—	—	—	—	188
16.	Rajasthan	—	—	—	—	3,282	466	—	16	—	—	—	—	—	—	3,764

Table 4.2 (*Contd.*)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	Total
17. Tamil Nadu	17	—	259	62	1,578	230	42	12	—	—	18	—	—	—	2,218
18. Tripura	—	—	635	—	—	—	—	—	—	—	—	—	—	—	635
19. Uttar Pradesh	—	—	1,151	—	1,276	204	—	—	511	—	—	1,055	17	357	4,571
20. West Bengal	—	—	459	279	430	—	—	5	—	—	5	—	—	5	1,183
21. Andaman and Nicobar Islands	635	—	—	—	—	—	—	—	—	—	—	—	—	—	635
22. Arunachal Pradesh	1,217	—	—	—	—	—	—	—	1,889	—	1,509	—	—	539	5,154
23. Goa, Daman and Diu	23	22	58	—	—	—	—	—	—	—	—	—	—	—	103
24. Delhi	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5
Total	4,503	1,854	23,303	671	29,154	5,236	75	287	3,740	173	1,613	2,725	277	1,790	75,351

The numbers in parentheses stand for different forest types as follows:

(1) Tropical wet evergreen
(2) Tropical semi-evergreen
(3) Tropical moist deciduous
(4) Littoral and swamp
(5) Tropical dry deciduous
(6) Tropical thorn
(7) Tropical dry evergreen
(8) Sub-tropical broadleaved hill
(9) Sub-tropical pine
(10) Sub-tropical dry evergreen
(11) Montane wet temperate
(12) Himalayan moist temperate
(13) Himalayan dry temperate
(14) Sub-alpine and alpine

SUB-GROUP 1B—NORTHERN TROPICAL WET EVERGREEN FORESTS

These forests are found in the northeastern parts of the country, particularly in West Bengal, Assam and Orissa. The mean annual rainfall varies from 250 to 630 cm with the number of rainy days varying from 95 to 150.

The top canopy consists of spp. such as *Dipterocarpus*, *Shorea*, *Mesua*, *Dysoxylum*, *Anthocephalus*, *Artocarpus*, etc. Among the shrubs, the common ones are *Clerodendron*, *Ixora*, *Miliusa*, *Pandanus*, *Garcinia*, etc. Canes, palms and ferns also occur.

SUB-GROUP 2A—SOUTHERN TROPICAL SEMI-EVERGREEN FORESTS

The forests of this category are found in the Western Ghats, north of Bombay in Ratnagiri district of Maharashtra, South of Cochin and in the Andamans. These forests occur in association with evergreen forests. Mean annual temperature where such forests occur is about 26°C. The mean annual maximum and mean annual minimum temperatures are about 30 and 22.5°C respectively. The mean annual rainfall varies from 180 to 300 cm, but common range is 200-250 cm. The important climax forests recognised under this sub-group are: (i) Andamans semi-evergreen forest; (ii) West-coast semi-evergreen forest; and (iii) Tirunelveli semi-evergreen forest. The important spp. of top canopy which are found in Andamans are *Dipterocarpus*, *Sterculia*, *Terminalia*, *Albizzia* and *Artocarpus*. Important species of understorey are *Lagerestroemia*, *Dillenia*, *Mallotus*, *Hydnocarpus*, *Bisochofia*, *Canarium*, *Kydia*, etc.

SUB-GROUP 2B—NORTHERN TROPICAL SEMI-EVERGREEN FORESTS

These forests occur in heavy to moderately heavy rainfall areas in Assam, West Bengal, Orissa and other northeastern States. The mean annual temperature is about 24°C, with annual mean maximum and minimum reaching 29 and 19°C respectively. The lowest temperature sometimes reaches 5°C. Average rainfall varies from 150 to 300 cm.

The special types recognised under this sub-group are: Assam Valley semi-green, Cachar semi-green and Orissa semi-evergreen types. The common trees of top canopy are *Artocarpus*, *Michelia*, *Phoeba*, *Dysoxylum*, *Terminalia*, *Mangifera*, *Elaeocarpus*, *Tetrameles*, etc., spp.

The underwood consists of *Phoeba*, *Mallotus*, *Ilex*, *Amoora*, etc. Bamboos especially *Melocana bambusoides*, *Bambusa arundinacea* and *Dendrocalamus hamiltonii* occur in these forests.

SUB-GROUP 3B—SOUTHERN TROPICAL MOIST DECIDUOUS FORESTS

This important type occurs in Jabalpur, Mandla and Raipur Forest divisions in Madhya Pradesh, Dangs division in Gujarat, Nilambur and Wynad divisions in Kerala. Coimbatore and Tirunelveli divisions in Tamil Nadu, Kanara and Mangalore divisions in Karnataka and Kolaba and Thana districts in Maharashtra. Many of the forests of this group contain commercially valuable teak. The mean annual temperature varies from 24 to 27°C, with mean maximum temperature of about 35°C in coastal regions, and about 42°C in central parts. The mean minimum temperature varies from 18°C in coastal regions to less than 5°C in north central parts. The rainfall in the area varies from 150 to 250 cm with a dry season of about four to five months.

This type can be sub-divided into very moist, moist and slightly moist teak forests. The very moist forests may contain only 10 per cent teak, the moist ones 10-25 per cent teak, while the slightly moist contain 25-65 per cent. In these forests other spp. of top canopy are *Grewia*, *Terminalias*, *Pterocarpus*, *Dalbergia*, *Albizzia*, *Bombax* etc. Underwood is abundant, consisting of *Kydia*, *Emblica*, *Gmelina*, *Cassia*, etc. Bamboo spp. occur, especially *Bambusa arundinacea*, *Dendrocalamus strictus*, etc. The shrubs include *Clerodendron*, *Lantana*, *Helicteres*, *Eupatorium*, *Desmodium*, etc., spp.

SUB-GROUP 3C—NORTH INDIAN TROPICAL MOIST DECIDUOUS FORESTS

This sub-group of economically important forests occurs in Uttar Pradesh, Bihar, Orissa, Madhya Pradesh, Assam and other northeastern States. The mean annual temperature lies between 21 and 26°C. The mean minimum temperature varies from 10 to 13°C. The highest temperature varies from place to place but it reaches more than 45°C at many places. The annual rainfall varies from 100 to 200 cm.

Sal or *Shorea robusta* is the most important spp. in this sub-group. Further variations of the group—very moist sal, moist sal, moist sal savannah, moist mixed deciduous and northern secondary moist mixed deciduous have been recognised.

Among the very moist sal bearing forests, further smaller groups, viz. eastern hill sal, eastern bhabar sal, east Himalayan sal, Khasi hill sal, eastern Himalayan upper bhabar sal, east Himalayan lower bhabar sal and eastern tarai sal forests are recognised. The associated spp. of sal are *Schima wallichii, Stereospermum personatum, Chukrasia tabularis, Adina cordifolia, Gmelina arborea, Lagerstroemia parviflora, Bombax ceiba, Albizzia odoratissima*, etc. The underwood consists of *Emblica officinalis, Careya arborea, Dendrocalamus hamiltonii, Mallotus philippensis* and other species.

GROUP 4—LITTORAL AND SWAMP FORESTS

These are evergreen forests on wet sites, sub-divided into littoral forests on coastal sand, tidal swamp forests on estuarine sand, fresh water swamps on wet alluvium and riverine fringing forests. Among the important spp. are *Casuarina, Heritiera, Manilkara, Rhyzophora*, etc. Undergrowth consists of canes and ferns.

SUB-GROUP 5A—SOUTHERN TROPICAL DRY DECIDUOUS FORESTS

These forests occur in Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Gujarat, Madhya Pradesh and Rajasthan.

The annual mean maximum temperature lies between 29 and 35°C and the annual mean minimum temperature between 18 and 23°C. Lowest temperature may reach below 0°C at places. The maximum temperature during summer may reach up to 48°C. The typical rainfall in the area is about 100–130 cm, but it may vary from 85 to 190 cm annually, with a dry period of about six months.

Further sub-types, viz. dry teak bearing forests, dry red-sanders bearing forests, southern dry mixed deciduous forests and very-dry teak forests (viz. Chittorgarh, Udaipur, Aurangabad and Akola) are recognised.

The common associates of teak are *Boswellia serrata, Anogeissus latifolia, Sterculia urens, Pterocarpus marsupium, Emblica officinalis, Madhuca latifolia*, etc. The common bamboo in the area is *Dendrocalamus strictus*. *Santalum album* also occurs in certain areas. Dry red-sanders bearing forests occur in Andhra Pradesh, the main spp. being *Pterocarpus santalinus*.

SUB-GROUP 5B—NORTHERN TROPICAL DRY DECIDUOUS FORESTS

These forests occur in the drier parts of northern Madhya Pradesh, Orissa, Bihar, West Bengal, Uttar Pradesh and Haryana. The average annual temperature varies from 20 to 26°C. The mean maximum temperature lies between 29 and 33°C with maximum temperature touching 48°C during summer. The mean minimum may range between 15 and 21°C, but during some nights temperature may go below the freezing point. The average annual rainfall in the area may range between 75 and 120 cm.

Two sub-types, viz. dry sal bearing forests and northern dry mixed deciduous forests are recognised. The former occur in Siwalik hills and Gangetic alluvium in Uttar Pradesh and in hilly tracts of Bihar, Orissa, Madhya Pradesh, and West Bengal. The sal is of quality IV and III and has its associates *Anogeissus latifolia*, *Buchanania lanzan*, *Terminalia tomentosa*, *T. bellerica*, *Diospyros tomentosa*, *Madhuca latifolia*, etc.

The northern dry mixed deciduous forests occur almost in the entire dry tracts of the northern region.

SUB-GROUP 6A—SOUTHERN TROPICAL THORN FORESTS

These forests occur in the dry areas of Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu. The mean annual temperature varies from 24 to 28°C. The average annual rainfall lies between 45 and 95 cm with the number of dry months varying from four to nine but generally seven or eight. Important species are *Acacia nilotica*, *A. leucophloea*, *A. catechu*, *Azadirachta indica*, *Zizyphus* spp., *Prosopis* spp., *Euphorbias*, etc. *Acacia planifrons* characteristically occurs in such forests in Tamil Nadu and Karnataka forming an umbrella shaped crown.

SUB-GROUP 6B—NORTHERN TROPICAL THORN FORESTS

These forests occur in semi-arid regions of Uttar Pradesh, Madhya Pradesh, Punjab, Haryana, Rajasthan and Gujarat. The average annual rainfall varies from 20 to 70 cm with 15 to 40 rainy days.

Three sub-groups are recognised, desert thorn forests, ravine thorn forests and Runn thorn forests. The common spp. in the first sub-type are *Prosopis spicigera*, *Salvadora* spp., *Calotropis gigantea*, *Euphorbias*, etc. In ravine areas *Acacia nilotica* also occurs, while the Runn areas consist of *Salvadora*, *Tamarix*, *Calotropis* spp., etc.

GROUP 7—TROPICAL DRY EVERGREEN FORESTS

Such forests are restricted to the East Coast from Tirunelveli to Nellore, common spp. being *Manilkara*, *Mimusops*, etc.

SUB-GROUP 8A—SOUTHERN SUB-TROPICAL BROAD LEAVED FORESTS

These forests are found between 1,000 m and 1,700 m on the hills of South India and about 1,000 m in Central India. The sub-types recognised are Nilgiri sub-tropical forest, Western sub-tropical (Mahabaleshwar) and Central Indian subtropical forest (Madhya Pradesh, Panchmarhi, Rajasthan—Mount Abu). The vegetation is a mixture of tropical and temperate areas. In Nilgiris, the important spp. are *Calophyllum Cinnamomum*, etc. with a dense undergrowth of *Strobilanthes*.

SUB-GROUP 8B—NORTHERN SUB-TROPICAL BROAD LEAVED HILL FORESTS

These forests occur on slopes of eastern Himalayas from 1,000 to 2,000 m. The important species are *Castanopsis* spp., *Schima*, *Michelia*, *Quercus* etc.

GROUP 9—SUB-TROPICAL PINE FORESTS

Such forests occur throughout western, central and eastern Himalayas, from Jammu and Kashmir to Nagaland and Manipur between 600 and 2,000 m in altitude. These forests are economically important, main spp. being *Pinus roxburghii* in the western and central Himalayas, and *Pinus insularis* in Khasi, Naga and Manipur hills. The mean annual temperature varies from 15 to 20°C, with mean annual maximum ranging from 20 to 26°C and mean annual minimum from 10 to 15°C. The average annual rainfall lies between 100 and 300 cm with number of rainy days varying between 75 and 125.

Two sub-types are differentiated, the Himalayan sub-tropical pine forests and the Assam sub-tropical pine forests. In the Himalayan sub-tropical pine forests, apart from *Pinus roxburghii*, the other spp. are *Mallotus philippensis*, *Pyrus pashia*, *Albizzia chinensis* and in moister localities *Quercus leucotricophora* (Syn. *Q. incana*), *Q. glauca*, *Rhododendron arboreum*, *Myrica nagi*, etc. In the Assam sub-type, the associates of *Pinus insularis* are *Quercus griffithii*, *Q. serrata*, *Castanopsis* spp., *Betula alnoides*, *Acer oblongum*, etc.

GROUP 10—SUB-TROPICAL DRY EVERGREEN FORESTS

These forests occur in Siwalik hills and foothills of western Himalayas generally up to 1,000 m altitude. The important species are *Olea cuspidata* and *Acacia modesta*, its degraded stage being *Dodonea* scrub.

GROUP 11A—SOUTHERN MONTANE WET TEMPERATE FORESTS

These forests occur in Kerala and Tamil Nadu on the Nilgiri, Annamalai, Palani and Tirunelveli hills, from about 1,500 m upwards. Important trees are *Ternstroemia* spp., *Michelia nilagirica*, *Gordonia obtusa* etc.

SUB-GROUP 11B—NORTHERN MONTANE WET TEMPERATE FORESTS

These forests occur in the hills of West Bengal, Sikkim, Assam and Nagaland between 1,800 and 3,000 m. East Himalayan wet temperate and Naga hill wet temperate sub-types have been differentiated. The main species are *Machilus edulis*, *Michelia* spp., *Cinnamomum obtusifolium*, *Quercus lamellose*, *Acer* spp., high level oak *Quercus pachyphylla*, *Alnus nepalensis*, *Carpinus viminea*, etc.

GROUP 12—HIMALAYAN MOIST TEMPERATE FORESTS

These are important forests of western and eastern Himalayas, from 1,500 to 3,300 m in the States of Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, Arunachal Pradesh, West Bengal, Sikkim and Assam.

The mean annual temperature of the area is about 13.5°C with annual mean maximum and annual mean mini mum being about 18 and 9°C respectively. The recorded highest and lowest temperatures may be about 37°C (Srinagar) and many centigrade below the freezing point respectively. Quite a good amount of precipitation is received in the form of snowfall. Average annual rainfall varies from 50 to 200 cm.

Among the sub-types recognised are Ban oak forests, Moru oak forest, Moist *deodar* forest, western mixed coniferous forest, Moist temperate deciduous forest, and Low level blue pine forests in the lower western Himalayas. In the upper western Himalayan forests, *kharsu* oak forests, fir forests and moist temperate deciduous forests are differentiated. In the eastern Himalayas, mixed coniferous forests are recognised, with *Abies delavayi*, *Tsuga dumosa* and *Abies densa* etc.

GROUP 13—HIMALAYAN DRY TEMPERATE FORESTS

These forests occur in the inner Himalayas where the annual rainfall is below 100 cm, usually above 2,700 m, distributed in Ladakh (Jammu and Kashmir), Lahaul and Spiti, Kinnaur and Pangi (Himachal Pradesh), Inner Garhwal (Uttar Pradesh) and Sikkim. The main spp. in the west are *Quercus ilex*, *Pinus gerardiana*, *Cedrus deodara*, *Pinus wallichiana*, *Juniperus macropoda*, etc., while in the east, the main trees are *Picea spinulosa*, *Pinus wallichiana* and *Betula* spp.

GROUP 14—SUB-ALPINE FORESTS

These forests generally occur between 3,000 and 4,000 m in the Himalayas. The total precipitation usually is below 100 cm, most of it being in the form of snow. Some important spp. in the west are *Abies spectabilis* and *Picea smithiana*, while the eastern Himalayas commonly have *Abeis densa* and *Betula utilis*.

GROUP 15—MOIST ALPINE SCRUB

These forests occur in the whole length of the Himalayas generally about 3,500 metres in altitude, important spp. being *Betula utilis*, *Rhododendron campanulatum*, etc., trees being short and bushy.

GROUP 16—DRY ALPINE SCRUB

This type occurs in drier Alpine areas, the common species being *Juniperus communis* and *J. wallichiana* in the western Himalayas and *J. recurva* in the eastern Himalayas, the height of these not reaching above 2 m.

CHAPTER 5

Forests and Environment—Climate

Forests influences

While climate determines the forest types and forms, in turn, forests themselves affect the micro-climate. In this connection various factors influenced by forests are as follows:

i) Solar radiation and light
ii) Air temperature
iii) Wind
iv) Atmospheric moisture
v) Precipitation
vi) Interception and stem flow
vii) Fog drip
viii) Evaporation and condensation
ix) Snow
x) Soil evaporation
xi) Soil temperature
xii) Litter and forest floor
xiii) Soil moisture and
xiv) Transpiration.

SOLAR RADIATION

A forest canopy may reduce the solar radiation to less than one per cent of that in the open, and it increases with increase in (a) percentage of ground cover and (b) closeness of the spacing.

AIR TEMPERATURE

A forest cover in general reduces the maximum and raises the minimum temperature throughout the year, thereby reducing the annual, monthly or diurnal range of temperature. The mean temperature is generally lowered. Temperature effects of forests vary in different regions with the character and density of the cover.

WIND

When entering a forest on a windy day, one notices the relative calm caused by mechanical obstruction offered by the trees. The degree of influence of forest cover on wind movement varies with the height, length, width and density of individual crowns and with the density of the stand. The velocity of the wind in the interior of a forest may range from about a tenth to two-thirds of that in adjacent open country, depending on the character and condition of the forest.

ATMOSPHERIC MOISTURE

In general the air in a forest is more moist compared with that in the open. The relative humidity may be 10 per cent higher in the forest than in the open, and in tropical forests, the point of saturation is reached.

PRECIPITATION

From experiments conducted in other countries, it has been found that the forests have no pronounced effect on the amount of rainfall and its distribution. Although the forest transpires a large amount of water, which will be certainly higher than the evaporation from an open lake, the enlarged humidity is still quite negligible compared to the amount of water vapour transported by wind action from other areas. However, forests may increase local rainfall by not more than 3 per cent, and the rainfall in clearings in the forests may be about one per cent or more than under similar conditions in the open.

INTERCEPTION AND STEM FLOW

Although forests do not noticeably affect general rainfall, their influence is not at all negligible in the amount and distribution of precipitation that reaches the ground locally. Beneath the crowns of the trees in a forest, a certain amount of precipitation is intercepted and then evaporated from the leaves, twigs, branches and trunks. Thus interception represents a loss of precipitation that would otherwise be available to the soil, and it is a function of the storage capacity of the surface of the vegetation, the evaporation rate during precipitation and the amount of precipitation per shower. Interception losses are large in regions with high evaporation and are usually low in regions where they are compensated by fog or cloud drip.

FOG DRIP

In regions with frequent fogs or fine mist, fog drip may increase the precipitation reaching the ground by amounts up to two or three times the precipitation in the open. This fog drip increases with the elevation of the crowns above the ground, with the area of vertical exposure of foliage surface and with the ratio of foliage to ground area.

EVAPORATION AND CONDENSATION

The net evaporation is the difference between the amount of vapour leaving a surface and the amount condensed on the surface. It may be positive, zero or negative. Evaporation is affected directly or indirectly by atmospheric pressure, wind velocity, atmospheric humidity, temperature, solar radiation and wetness of the evaporating surface. It has been seen that evaporation in the forest is less than in the open.

SNOW

Trees influence the accumulation of snow by interception and by reducing wind movement in and below the canopy. Falling snow is caught up on foliage, and the proportion evaporated to the air from the crowns is about the same as when precipitation is in the form of rain. The mass and weight of snow accumulation on trees is controlled by the form of tree crown in addition to the other factors. Kittredge found that evaporation must proceed much more rapidly in the crowns than on the ground surface to account for the measured interception losses. Snow melting is generally retarded in proportion to the density of tree cover.

SOIL EVAPORATION

The subject of evaporation in effect forms a transition from the consideration of influences of vegetation on climatic to those on soil factors. The soil factor that may be involved and may differ in different horizons of the soil profile from the forest floor to the parent material include texture, colloids, structure, depth, moisture, air, temperature, inorganic constituents, reaction, organic matter and soil life. Some evidence is available to show that evaporation from a soil saturated to the surface corresponds quite closely to that from a free water surface and decreases as the soil becomes drier. The evaporation from soil covered by forest is 10 to 80 per cent of that from bare soil.

SOIL TEMPERATURE

In most regions, soil temperatures under forest cover are lower in spring and summer, and higher in fall and winter than in the open. The influences are largest near the surface and become less with increasing depth of the soil. The temperatures of the subsoil below a certain depth are lower throughout the year under forest than in the open.

LITTER AND FOREST FLOOR

The annual leaf fall varies widely in the same stand in different years and is smaller on poor than on good site qualities. It is a function not only of the forest stand but of all the environmental factors, as they affect the fauna and flora and the biological and chemical processes of decomposition in the forest floor. Addition of leaf fall to soils of poor sites increases forest growth and removal of forest floor or its excessive accumulation as peat or raw humus deteriorates site quality and decreases growth.

SOIL MOISTURE

Rain water after passing through the forest canopy wets the forest floor before any of the water passes down into the mineral soil. The minimum amount of water retained by absorption and film forces when the water is free to move downwards through a mass of soil is known as "normal moisture capacity" or "field moisture capacity". There are two important phases of moisture in the mineral soil—retention or storage, and infiltration (and percolation). Both affect, although in different ways, the amount of water that passes down to the water table and reappears in stream flow. Infiltration is the process by which liquid water enters the surface soil or zone of aeration. The term percolation is sometimes used in the same sense but that is the movement of water below the surface layer of the soil. The presence of a dense cover of vegetation tends to promote infiltration. The vegetative cover not only provides protection from compaction due to rain but also provides a layer of decaying organic matter which promotes the activity of burrowing insects and animals. The effect of cover may be even more important than soil type. A protected soil may have many times the infiltration capacity, than it has when it is barren.

TRANSPIRATION

From the point of view of influence of forest, transpiration is one of the sources of loss of water of precipitation along with interception and evaporation before the remainder appears in stream flow. This loss of water vapour from plants is an evaporative process but it differs from normal evaporation in the following manner: (a) The location of the evaporative surface is above the ground. (b) There is considerable distance between source and evaporative surface. (c) There is a degree of control over the process by the living plant. It is thus, perhaps, the most complex of all evaporative processes and is regulated by (i) the meterological factors; (ii) the conditions within the plant; and (iii) the water relations of the soil.

In the majority of plants, stomata are open in the day and closed at night and different plants respond differently to the same factors. When stomata are open, transpiration is a function of the inner surface area and the temperature of the leaves. The thick leaves characteristic of so-called xeromorphic structure and of "sun leaves" have greater inner surface than have mesomorphic leaves or shade leaves. Transpiration increases rapidly with increasing leaf temperature.

Enormous quantities of water are removed by the vegetation from the soil by transpiration. A well stocked forest of mature trees uses more water than does any other form of vegetation.

In general a forest cover requires up to 1,400 pounds of water for every pound of dry matter produced, while the quantity of water varies for different species.

Shelter-belts

Forests play a major role as shelter-belts. Investigations have led to the following conclusions:

1) Sheltered zone on leeward side (before incident flow is re-established) extends to approximately 30 times the height of the belt. For 20 per cent reduction, this zone extends to 15–20 times the height.

2) A dense belt provides greater shelter immediately to leeward, but the sheltered distance is less, compared to a more permeable belt. A moderately penetrable belt is the best.

3) The shelter effect is mainly a function of height and penetrability; width influences the general microclimate but not the reduction in wind velocity.

4) A belt which both rises and falls abruptly on windward and leeward sides is said to be most effective. The smaller trees and shrubs should occupy the interspaces between the tall trees.

5) The maximum effect is obtained (at least in the centre) if the length is not less than 12 times the height.

6) In a vertical direction the influence on wind velocity extends to more than four times the height.

7) In respect of soil blow and wind erosion, the protective effect extends to about 30 times the height, the maximum being at about 14 times the height.

8) The temperature range is reduced, humidity is increased and greater dew fall occurs on the leeward side. The influence on evaporation extends to about 10 times the height, the area of greatest protection varying from immediately leeward to about five times the height, depending upon whether a wide dense stand or a permeable narrow belt of trees is an effective barrier.

Changes in climate

A series of pre-historic cultures once flourished in the north-west of the Indian sub-continent. As H.S. Mann has pointed out, the Indian desert has resisted orogenic forces and has been subjected to marine transgressions. In geological times the aridity has become established in the region after a series of wet and dry phases.

Krishnan opined that the present pattern of rainfall in north-west India must have set in during the tertiary period, when the Himalayas rose high enough to become an obstruction, but that the general lowering of temperatures during the Ice Ages must have kept Rajasthan moist till perhaps sub-recent times. Piggott concluded, from such evidence as the presence of paved drains in Harappan settlements, the timber used in the dwellings and the animal remains, that the climatic conditions during that period—*c*. 3000 to *c*. 1500 B.C.—must have been appreciably more moist than they are today. Bryson and Barries advocated a recent onset of aridity and attribute it to over-exploitation of vegetation, resulting in accelerated wind erosion, increased atmospheric dust and consequent reduced precipitation. However, many divergent views have also been expressed by others. Roy and Pandey state that desert conditions in the tract set in with the rise of Himalayas and the establishment of the monsoon regime. They do not believe that the decline of pre-historic cultures signifies any change of climate. They argue that the various archaeological sites are located along river courses, and that shift of courses, a process not uncommon in the tract, alone could cause adverse conditions for the collapse of these cultures. Likewise, Meher-Homji believes that the type and thickness of calcareous pans in the arid zone soils indicate that climate in the area has been basically dry for the past several thousand years, and possibly even more. Similarly, Dhir also suggests that the profile organisation and genetic features in soils even of land-forms that have remained stable during the Holocene wind activity, do not show manifestations of a humid climate. Though the moisture regime was probably wetter than it is today, the soil formation in the area is characteristic of arid and semi-arid conditions.

Seth (1961) had sifted archaeological, historical, literary, sculptural and scientific evidence in order to determine if any provable change of climate has taken place in the Indo-Pakistan subcontinent during the proto-historical and historical periods, whether the flora has changed significantly, and finally whether there has been a natural change in climatic conditions leading to vegetational adjustments or, contrariwise, the interference with natural vegetation has caused a deterioration in the prevailing climate. Recent investigations into the climate of India with particular reference to rainfall show that in general there is no tendency for increase or decrease in rainfall. In the arid and semi-arid regions of north-west India, there has been a slight deficit, whereas there is slight excess in the north-east. No significant change is occurring in the rainfall of Rajasthan, the values of coefficient of variation showing a marked correlation with the amount of dryness. With regard to temperature, it is again apparent that there is no general tendency for a systematic increase or decrease in maximum and minimum temperatures, but at some places there are variations of an oscillatory character with a period of 30-40 years.

HARAPPAN PERIOD (CIRCA 3000 B.C. TO CIRCA 1500 B.C.)

As a result of excavations carried out during the last 40 years, it has been revealed that the Indus Valley was the seat of a highly evolved chalcolithic culture in proto-historic times during circa 3000 B.C. to circa 1500 B.C. The main features of Harappa culture (as it is called from the present name of the village occupying the site of its northern metropolis on the Ravi river in the Punjab), or the Indus civilisation (so-called from its main axis which lies along the Indus with the southern capital at Mohenjodaro) in which we are interested are those which throw light on the climate and vegetation prevailing in the Indus Valley in its hey-day.

The known remains of this culture occupy a huge irregular triangle, from the foot of the Himalayas to the Makran coast, Kathiawar and Gujarat, Bahawalpur and northwestern Rajasthan, measuring 1,500 × 1,100 × 850 kilometres. With rare exceptions, they are towns or villages of the plains, mostly clinging to present or former courses of rivers, still flowing or long since vanished, and belonging to the Indus and western Gangetic system.

In Baluchistan, however, Aurel Stein was able to identify stone built dams and terraces to aid irrigation. These barrages and dams reflect not only a greater rainfall requiring storage, but prosperous agricultural communities in prehistoric times, as contrasted with the barren nature of the terrain at the present day and the precarious nomadism of the population.

The use of timber and wood on quite a large scale is attested by several facts. Enormous fortifications with burnt-brick revetments were raised around the metropolises of Harappa and Mohenjodaro. Kiln-fired bricks were also used for building purposes. However, in general their use was more common in the cities and larger settlements along the water courses.

The use of kiln-fired bricks in stupendous quantities implies two things—firstly the fuel required for burning the bricks should have been available relatively easily and in close proximity, and secondly the climate demanded something more durable than the mud bricks universally used in the empires of the ancient East. From these arguments and from the complementary evidence of elaborate systems of paved drains, it is postulated that rainfall was more frequent as well as more considerable and consequently the timber resources far more abundant than the present tamarix and scrub.

This view is, however, not shared by all archaeologists. Childe draws a parallel between the Mesopotamian, Egyptian and Indian civilisations, all of them islands of culture in a desert scrub, dependent upon inundations of a mighty river, and observes that while low rainfall and lack of building timber were common characteristics, the Harappan environment differed in its vaster expanse, in the regime of the flood, in its scrub of ugly useless trees and in the animals sheltered by them. The stupendous quantities of fuel required for firing the bricks were presumably gathered laboriously from the ugly trees that even now disfigure the desert.

VEDIC PERIOD (CIRCA 1500 B.C. TO CIRCA 300 B.C.)

Detailed and accurate information about the vedic period is lacking, and as shown later, no reliance can be placed on descriptions of forest composition. However, much evidence of a general nature is forthcoming to show that extensive forests covered the Indo-Gangetic Plains and the rainfall was probably more frequent and intense. There is reference to the famous Khandawa forest between the Yamuna and the Ganges in the vicinity of Hastinapur, and the great difficulty experienced in burning it (as Indra kept on pouring rain), presumably for cultivation and pasture. By the time of the Ramayan (Circa 5th to 3rd century B.C.) much of the forest had been cleared.

The khadar and khola (high bank) of the Ganges still support a forest essentially similar to that from which Hastinapur material would have come. The riverain vegetation contains *Dalbergia sissoo* and *Saccharum spontaneum*, and *Holarrhena* occurs in the dry miscellaneous forest. It may be surmised that in essentials, the vegetation and by inference, the climate, have not changed in any significant respect during the last 3,000 years. (Rice mentioned in the *Atharvaveda* (circa 1000 B.C.) has also been found at this site). Rice culture may have depended upon irrigation of some sort. The site is liable to floods, which destroyed the ancient settlements, time and again.

HISTORICAL PERIOD (CIRCA 300 B.C, TO DATE)

N.S. Randhawa collected information from many sources, literary and sculptural to show that desiccation has taken place in northern India in historical times. His main conclusion is that northern India especially the region around Mathura had a rainfall of 200 cm or more in the first and second century A.D. while the present rainfall is around 63 cm.

Quoting from *Mahabharata* (circa 5th century B.C. to 3rd century A.D.) where sal (*Shorea robusta*), *tal* (Palm), mango (*Mangifera indica*), *kadamb* (*Anthocephalus indicus*), *mahua* (*Madhuca indica*) and *arjun* (*Terminalia arjuna*) are described as growing in the Dwait forests, he opines that this shows that *kadamb* was growing in the northern plains.

Seth (1961) studied the matter further and concluded that the list of trees on which Randhawa based his conclusions is a kind of generalised list in which the poet had included whatever he thought beautiful. Seth (1961) wrote that "anybody with forest knowledge of Indian flora will see that the conclusion of Randhawa is devoid of any scientific value". The collection of trees quoted in many of our literary books again, in fact, grow nowhere together. Ashoka (*Saraca indica*) and *kadamb* (*Anthocephalus indicus*) both had a ritual and iconographic significance which is no index of their ubiquity in northern India. As Seth says the existence of extensive *kadamb* forests in ancient times and the reported occurrence of many remnants in the present period in the region of Mathura also seems to be based on a misconception. The people of this tract always refer to *Mitragyna parvifolia* as *kadamb*, and indeed the tree is by no means uncommon in many of these localities. It belongs to the same family (*Rubiaceae*) and has a ball like inflorescence, only slightly smaller than that of *kadamb* in size. It also grows in clayey, moist, waterlogged areas or near stream banks and it is quite certain that recent references to *kadamb* in the Mathura region always refer to *Mitragyna*. It is indeed likely that the humble *Mitragyna* and not the stately and lush *Anthocephalus* may have been the tree beloved of Krishna.

That the climate of Kathiawar during Ashoka's reign (circa 240 B.C.) must have been such that precipitation required to be carefully hoarded is evident from the construction of a dam which created the Sudarshana lake near Junagadh in Girnar. Rudradaman's inscription of 150 A.D. mentions repairs to a breach in the reservoir. This dam was again breached and was repaired by Skanda Gupta's Governor in 457-58 A.D. It had, therefore, a useful life of at least 600 years. When it was breached last is not known. Sudarshana lake exists no longer.

The accounts of Chinese travellers, Hiuen-Tsang and I-Tsing give some information about the climate and vegetation. Hiuen-Tsang travelled throughout India during the middle years of the 7th century A.D. He records in his travel diary that in general the plains below the western mountains were dry and saline; there were dense and shady forests and rice was cultivated near Jullundur (a typically dry tract now); *Phyllanthus emblica* was grown on a large scale near Mathura; there were dense forests near Varanasi; Malwa was well forested and finally that at Broach, at Atali near Kutch and in Saurashtra and south-western Rajasthan the soil was saline and/or sandy, trees were few and many dust storms occurred. He had to cross a formidable stretch of desert to reach Sind from Gurjardesh (Barmer). On the other hand, the soil of Multan was described as good and fertile and the climate as mild and pleasant. This indicates that while desert conditions had settled in the lower Indus Valley, the south-western part of Rajasthan around Barmer and the Punjab plains from Multan to Jullundur had not been desiccated to anything like their present condition. The development of extreme aridity in many parts of Rajasthan (except for the

Thar core) and in the Punjab plains is thus a comparatively recent phenomenon.

Several plant materials recovered during excavations from Sisupalgarh near Bhubaneswar, Orissa and Arikamedu near Pondicherry have been analysed at the Forest Research Institute, Dehra Dun. The analysis confirms the general impression that there has been no significant change in the climate and the type of vegetation associated with it.

It has been conjectured that the great Rajput kingdoms would not have flourished were it not for the fact that even towards the beginning of the Christian era, Rajputana was forested and far less arid. In this connection it should, however, be noted that the great dynastic cities of the Rajputs occurred east of the Aravallis in the basin of the Ganges, drained by the Chambal and its tributaries. Jaipur, Jodhpur, Udaipur, and Ajmer occupy a region which has a far more favourable climate than the western desert.

We may, therefore, agree with Seth (1961) in concluding that while a certain degree of desiccation has certainly taken place, the vegetation and climate in northern India were not much different two thousand years ago from what they are now. Disforestation has proceeded apace and this has affected the local climate rather than that natural climate has changed and has caused a profound change in the climax vegetation. In fact even as late as 1017 A.D. when Mahmud of Ghazni attacked Mathura, there were forests near Mahavan (great forest) dense enough to obstruct the movement of armies. The forests were thick but probably they comprised much the same species of trees as still grow in favourable situations in the tract.

According to some authorities western Rajasthan was largely occupied by a sea during the Jurassic, Cretaceous and Eocene, and outcrops of Jurassic sandstone and limestone occur at Jaisalmer. It was probably raised into dry land sometimes in the upper Tertiary. The sea extended to the Luni basin up to Panchbhadra and occupied the Rann and the lower portions of the Indus Valley in post-Tertiary times.

The whole central Asian region has been drying up for thousands of years and the Indus basin and Rajasthan may as well have formed a part of same system. The desert topography has, however, evolved within comparatively recent geological time as a result of dryness that has overcome the region since the Pleistocene. There is no high range to intercept the moisture bearing monsoon. Intense solar action, drought, extremes of heat and cold and wind action lead to considerable mechanical disintegration. The sand is partly derived from this source but a larger portion comes from the former sea shore and from the river channels, old and new, and the bed of Indus. Powerful summer winds transport these debris leading to the formation of sand dunes, as well as the widespread loose deposits of north-west India. The desert conditions are hence accentuated with time as the area is cut off from water circulation, except for occasional cloud bursts in the rains, and the water action of the internal drainage is too feeble to transport the blown sand to sea.

The sand hills are of great antiquity and often show signs of denudation. Given a dry climate, scanty rains, an inexhaustible source of sand from the former coast line, and powerful summer winds capable of raising tremendous dust storms, the formation of limitless wastes of blow and shifting sand is inevitable. If the cutting down of trees further accentuates insolation, increases evaporation, creates conditions for the development of violent winds and removes obstruction and surface drag in the path of such winds, the creep of the desert is very much accelerated and sands are blown on, deposit over, and engulf larger and larger tracts of fertile land at the edges.

The ensemble of historical and archaeological studies argues in favour of a stability of climate in terms of historical times in India. In India, deterioration in local conditions has been largely caused by local influences which have modified the temperature and humidity regimes, infiltration and surface drainage, wind movement and insolation and a host of interrelations of climatic elements. The evidence from Israel, Tunisia and India supports the primacy of human rather than natural climatic factors. There is wide agreement that the derelict Roman ruins in Algeria, the Central Asian ruins in Balkh and beyond point towards man rather than unaided climate as the chief agent responsible for devastation.

There is a widespread belief that destruction of forests has caused a change of climate. There is no doubt that extensive forests do affect the climate considerably. A barrier of trees protects the land from wind desiccation, reduces soil blow and modifies the temperature and humidity regimes. If all the vegetative cover were reduced from a large enough tract, remarkable changes are sure to follow. The temperature would rise steeply, the temperature differential between land and sea, and land and upper atmosphere would change the pattern of wind circulation both horizontally and vertically, and consequently the balance between wet and dry air currents. This is apparently what has happened, not in one step, but as a cumulative result of denudation over a long period of time.

Leaving aside the question of any change in the natural climatic zones, the process of desiccation may be brought about by the over-utilisation of vegetation covering the soil. This results in lowered productivity, decrease in surface water supply in springs, streams and wells, and dimunition in underground water resources associated with a sinking water table. Desiccation under these conditions may be enhanced by proximity of desert areas from which strong dry, hot or cold winds usually blow which cause accelerated evaporation as well as sand penetration.

It is evident that such conditions have prevailed in the Indus Valley, in particular during the last one or two thousand years, and in conjunction with a slight shift in the range of south-west monsoon have led to the development of extreme aridity. The region is a critical one, with innate potentialities of harsh developments such as the prevalence of strong summer winds and plenty of sand for them to lift, and destruction of even such scrubby vegetation as the area now has or had from the beginning tilts the balance in favour of the desert. In this region at least, both climate and man appear to share the blame for the present condition.

In conclusion it may be stated that while there is likelihood of climate having changed somewhat, especially in the Lower Indus Valley and Rajasthan, the destruction of vegetation has materially contributed to the deterioration in the climatic conditions. In the rest of the country, the extermination of native vegetation over large tracts has been the main factor responsible for worsening the environmental conditions and causing a consequent change in the succeeding flora.

CHAPTER 6

Forests and Environment: Soil Erosion and Floods

Soil erosion

This chapter examines how far the existing forests satisfy the physical and climatic needs of the country. It also gives a synoptic view of the soil erosion and land degradation in the country and also what role the forests should play in improving this situation. The vital importance of forests in this respect lies in (a) moderating extremes of heat and cold and affording protection against strong winds, hot or cold, and (b) in preventing soil erosion and reducing run-off especially on sloping grounds thus regulating streamflow, preventing siltation of rivers, rendering them navigable, tending to reduce floods and preventing destruction of agricultural land.

The soil of a country is its most important asset. It has been estimated that it takes a thousand years to produce 2.5 cm of mature soil. The most important ingredients of the soil—humus, organic matter, chemicals and nutrients which form the food on which a plant feeds—are stored in the top few inches of the soil. Once the layer of the top soil is lost, the soil fertility is so reduced that it can no longer support vegetation of any but the poorest type. If natural cover is destroyed, the top soil is exposed to the desiccating action of the sun, erosive violence of torrential rain and strong winds and is swept away in a few years.

It is the removal of the soil by the agency of wind or water action that is called erosion. In the earlier stages, the soil is removed in the form of a thin sheet, and the phenomenon is called sheet erosion. If it is not stopped in time, the clogging of the natural pores of the earth from sediments washed down by rains eventually interfere with the seepage and percolation. The actual runoff is thus increased, and the silt and pebble-laden water running over the surface acts like a file in rasping away more surface soil. Not only is the surface rubbed away, but tiny gullies called finger gullies are formed and soluble chemicals are washed away. Gradually clefts appear in the top soil, cutting right through to the subsoil, and erosion proceeds at an ever-increasing rate. The gullies produce excessive drainage, while the level of the underground water supply falls.

Closely associated with soil erosion is the increased run-off of water from deforested areas. The litter on a forest ground acts as a dynamic sponge not only in its capacity to retain the moisture, but chiefly in maintaining the soil surface below the litter in a condition of maximum rate of in-take.

Forest cover

Normally, forest with its normal ground cover is better than any other form of land management to prevent run-off and soil erosion. Further, it is not the normal rainfall that does damage, but a single infrequent and heavy storm which by cutting out gullies starts a new cycle of erosion. This is especially the case in many parts of India where the quantity of annual rainfall often consists of a few heavy storms. As quoted by Howard (1944) from comparable experiments the general proportions of the run-off and soil loss in single heavy storm for three different kinds of cover were found as follows:

Cover	*Run-off*	*Soil loss*
Forest	1	1
Grass land	27	32
Barren land	125	800

With the concentration of the Indian rainfall mainly in a few monsoon months, the great importance of maintaining forest cover especially in the hilly and undulating regions is obvious.

Causes of soil erosion

The intensity of erosion in general varies with the following factors.

1) *Climate:* Erosion being more marked in dry regions subject to occasional heavy downpours of rain.

2) *Gradient:* The steeper the gradient, the greater the chances of erosion.

3) *Run-off of water:* The greater the water running off in a given time, the more the erosion.

4) *Geological formation:* Soft friable formations, such as schists and shales are more liable to erosion than harder rocks; loose sandy soils are very liable to erosion.

5) *Presence or absence of vegetative cover:* Forest cover affords excellent protection against erosion; pasture land is good, but bare land is worse in places, where erosion is of any consequence.

6) *Presence or absence of litter:* Litter helps to prevent erosion.

7) *Grazing and burning:* Tend to compact and harden the soil, make it less absorptive of moisture and finally more liable to erosion.

The causes of soil erosion are pre-eminently present in India. The important factors contributing to soil erosion are deforestation or inadequate protection by vegetative cover, excessive grazing, lopping and burning, shifting cultivation and cultivation on unterraced slopes or other faulty techniques of agriculture. Some or most of these causes occur with distressing frequency in different parts of India over extensive regions.

Extent of soil erosion in India

F.L. Brayne, a development expert of pre-independence India considered soil erosion as the biggest single cause of poverty in India. T. Vijayaraghavachariar (1944), Vice-Chairman of the Imperial Council of Agricultural Research said that soil erosion was taking place over considerable parts of India, and reckless felling of forests had intensified the evil by producing floods where none existed before. Glover (1944), Chief Conservator of Forests of the Punjab estimated that at a very low estimate, soil erosion in pre-partition India was seriously lowering the productivity of 64 m ha of agricultural land.

Wrote Glover—"For progress, mental, moral and economic, man with his domestic animals, must live in harmony with his surroundings. Man has destroyed the forest, has cultivated fields for a short time on steep slopes until rain has swept away the soil, has allowed his flocks and herds without restriction to browse and graze on hill sides until the vegetation has been destroyed, and the earth and the rocks have been laid bare. Over many parts of India the balance has been disturbed and nature has taken a terrible revenge. Soil erosion is a creeping death; its effects are not confined to the land, but man suffers as well and accompanying the decline in arable condition is a lowering of human morale."

A Working Group of the Ministry of Agriculture, Government of India in 1968 estimated the area requiring soil and water conservation treatment in the country at 145 m ha.

The National Commission on Agriculture estimated in 1974 that 150 m ha of land in India suffered from serious water and wind erosion, sedimentation damage and other types of deterioration, out of which 69 m ha were in a critical state of deterioration, in the remaining areas of the country erosion being slight or none at all. This appears to be by far the most plausible estimate.

The Ministry of Agriculture in a brochure *Soil Conservation, Problem, Approach and Progress in India*, 1981, considered the broad distribution of soil erosion and land degradation problems of India under different land uses and special problems as in Table 6.1.

Life of multipurpose projects

The indirect losses caused by water erosion are equally serious. As Vohra (1980), an eminent land expert, has pointed out "the premature siltation of our 5,00,000 odd tanks and of the 487 reservoirs of our major and medium irrigation and multipurpose projects on which the community has invested over Rs. 10,000 crores during the last three decades, is a particularly serious matter. Observations show that the average rate of sedimentation in most reservoirs is four to six times as high as the rate which was assumed at the time they were designed and built. The life expectancy of these projects, is, therefore, being reduced significantly by soil erosion in their catchments. What

Table 6.1: Broad distribution of soil erosion and land degradation problems in India under different land uses and special problem areas

(Area in m ha)

Land use (using 1976-77 data)	Total area	Per cent of total taken as problem area	Problem area	Remarks
1	2	3	4	5
1.0 *Cultivable land*				
1.1 Rainfed non-paddy	82.1	100	82.1	
1.2 Net irrigated area	34.8	0	0	
1.3 Unirrigated paddy area	23.3	0	0	
Net sown area	140.2		82.1	
1.4 Current fallows	14.3	25	3.6	
1.5 Fallow other than current fallows	9.7	50	4.8	
Total fallows	24.0		8.4	
1.6 Permanent pastures and other grazing grounds	12.5	40	5.0	
1.7 Misc. tree crops and groves	4.0	20	0.8	
1.8 Culturable wasteland	17.0	50	8.5	
Total of other cultivable land	33.5		14.3	
Total of 1.1 to 1.8	197.7		104.8	

2.0	*Forest land*				
2.1	Reserved forest	39.0	10	3.9	*Figures detailed from Forestry Division, Dte. of E & S figures is 66.8 m ha
2.2	Protected forest	23.2	40	9.3	
2.3	Unclassed forest	12.6	50	6.3	
	Total forest	74.8*		19.5	
3.0	*Area not cultivable and not under forest*				
3.1	Under non-agricultural uses	17.5	20	3.5	**Reporting area as per Dte. of E & S is 304.0 m ha. Difference due to difference in the figures on forest area under Sl. 2 given by Dte. of E & S and Forestry Division
3.2	Barren land	21.9	20	4.4	
		39.4		17.9	
	Grand total land usewise distribution	311.9**		132.0	
4.0	*Special problem areas**				
4.1	Gullies and ravines		100	4.0	Threaten another 4 to 5 m ha of productive table lands
4.2 & 4.3	Alkali and saline		100	7.0	
4.4	Shifting cultivation		100	2.8	
4.5	Riverine land (*khadar/diara/rao/char/bill*)		100	2.5	
4.6	Torrents, stream banks		100	0.2	
4.7	Desert		80	18.8	
4.8	Coastal sandy land		25	1.6	
4.9	Waterlogged areas		100	6.0	

is particularly alarming is the fact that in most cases there will be no alternative sites for dams once the existing ones are rendered useless. This means that even if we have the money to build fresh projects—and this is by no means certain—we shall not have the physical opportunities of doing so. What is at stake, therefore, is the loss of the irreplaceable potential—for irrigation, for electricity and for flood control—that these storages represent".

When our multipurpose projects were designed after independence, very little data of hydrology and sedimentation was available in this country. There was urgency about their construction to bring in a fast increase in the irrigated area of the country and the development of power, and little investigation was made with particular reference to the silt in-flow. It was presumed in most of them that the dead storage that is reserved for silt in-flow should be large enough to sustain the economic life. An earlier study of reservoir silting by collection of data from various reservoirs in the world estimated the average annual rate to be 75 to 90 ac ft per 100 sq miles of catchment area. Apart from this, the position was masked by the apparent long life of a few small reservoirs existing in India, and the relatively less severe problem in the United States where the earlier problems were gradually solved following the agricultural depression in the early thirties, and large-scale conversion of agricultural lands into forests and grasslands. As much as 68 per cent of the land area in U.S.A. in 1970 was forests and grasslands and another 12 m ha of forests were to be added up by 1980, to protect 700 m ac ft of the surface storage for flood control, irrigation and power, etc.

The first set of capacity surveys conducted under a Central Board of Irrigation and Power research scheme in India during 1962-64, brought out a different picture of the problem of siltation, in which it was found that the rate of silting showed an increase up to 510 ac ft, i.e. up to nearly 600 per cent of the anticipated all-India rate and sometimes very much more than those figures given by the designers which were even lower. The data of such surveys and suspended inflow observations, i.e. the difference between assumed and observed total annual quantities is given in Table 6.2.

The life of reservoir starts getting affected even before the

Table 6.2: Difference between assumed and observed total quantities

Sl. No.	Project with year of first impounding of water		Assumed annual sediment inflow in ac. ft.	Observed annual sediment inflow in ac. ft. (in both live and dead storages)	Estimated life of project (according to dead storage in years)	Revised life (dead storage equivalent theoretical) (in yrs)	No. of yrs. needed to fill up 50% of live storage acc. to current silting (mostly incl. dead storage also)	Balance life in yrs. (live storage)
1.	Bhakra	1959	19,000	28,000	88	47	147	105
2.	Hirakud	1956	16,892	24,300	110	35	82	41
3.	Maithon (DVC)	1957	684	7,714	246	24	60	36@
4.	Panchet	1959	1,982	12,000	75	12	21	8@
5.	Ramganga	1972	1,089	4,366*	135	47	223	177
6.	Tungabhadra	1959	9,796	41,058	36	3	40	37
7.	Mayurkashi	1955	538	30,000	100	18	92	73
8.	Kangsabati	1965	1,000	4,389	100	27	99	82@
9.	Nizamsagar	1931	530	19,148	178	5	35	15@

*Suspended observation

@Flood storage excluded

dead storage meant for trapping reservoir silt is filled up. The total utilisable storage provided for in a project gets reduced by siltation. There is a reduction of live storage right from the year of impounding as the velocity of water gets reduced as soon as the flow reaches the reservoir.

The statement below, as compiled by the National Commission on Agriculture from data obtained from the Central Water Commission and Ministry of Agriculture and Irrigation, based on the capacity surveys of the reservoirs is revealing.

Table 6.3: Percentage loss of storage capacity in the different allocated zones and of the total capacity up to 1974

Name of reservoir	Loss in dead storage	Loss in live storage	Loss in total capacity	Remarks
Bhakra	16.0	2.5	5.6	Capacity survey conducted every year
Maithon	26.0	12.0	10.7	Projected over 1971 figures
Panchet	35.2	17.8	9.2	Capacity survey completed in 1974
Mayurkashi	21.2	7.7	9.2	Projected over 1970 figures
Tungabhadra	—	—	9.4	Capacity survey completed in 1972
Nizamsagar	100.0	60.4	62.0	Projected over 1967 figures
Lower Bhawani	100.0	3.8	4.0	Projected over 1965 figures
Matatilla	15.0	8.5	10.5	Projected over 1969 figures
Sivajisagar	—	—	0.8	Details not available

The Irrigation Commission for India identified the problem of location of sediment deposit in reservoirs and stated in this connection as follows:

"Some of the sediments in a river may be deposited upstream of a dam, some may pass through it without being deposited, but much of it is deposited in the dead storage, but some of it may also find its way into that portion of the dam which is reserved for live storage. The problem of encroachment on the live storage capacity is more acute in reservoirs like Hirakud where the waterspread area behind the dam is very large and silt is deposited in shallows on the edge of the lake."

Soil erosion: Himalayan region

The Himalayan region extends from the west to the east for 2,500 km and varies in its width from 250 to 300 km. Geographically, Himalayas are divided into three sub-regions, namely— (1) Western Himalayas consisting of the States of Jammu and Kashmir and Himachal Pradesh; (2) Central Himalayas consisting of eight districts of Garhwal and Kumaon Divisions of Uttar Pradesh; and (3) North Eastern Himalayas comprising the States of Sikkim, Hill Districts of Assam, Manipur, Meghalaya, Nagaland, Tripura, Union Territories of Arunachal Pradesh and Mizoram and Darjeeling District of West Bengal. The region is a complex fragile ecosystem spread over an area of 52 m ha which is 17 per cent of the total area of the country. According to the provisional figures released by 1981 census, the population of the Himalayan region is 42.94 m accounting for 6.3 per cent of the total population of the country, as against 32.47 m (5.9 per cent of the total) according to 1971 census. The population of the region has recorded an increase of 10.47 m, i.e. 32.3 per cent in the decade 1971-81.

The Western and Central Himalayan region together will be dealt with here while the North Eastern Himalayan region will be dealt with separately. There are large variations in topography, climate and soil conditions in the Himalayas representing areas from tropical valleys and hills to arctic mountains. As seen in the land use figures in Table 2.5, the Western Himalayas have about 52 per cent of the area under forests, about 13.6 per cent area is sown, 13.5 per cent area is barren and unculturable, while 2.3 per cent is shown as culturable waste, 1.6 per cent is fallow and 2.2 per cent is under groves, 3.2 per cent being under sites, buildings, roads and waters. The altitudinal distribution of areas under forests is roughly of the following order in the Uttar Pradesh portion of the Himalayas:

Table 6.4: Altitudinal distribution of areas under forest in U.P. portion of the Himalayas

Metres	Percentage
Below 300	10.0
300-600	9.8
600-900	6.3
900-1200	6.7
1200-1500	8.3
1500-1800	9.4
1800-2100	7.8
2100-3000	15.0
3000-3450	5.9
Above 3450	20.8
	100.0

Thus, the higher ranges supporting scanty to little forest growth or snows account for more than one-fifth of the area. The hill areas present some very special geological and geophysical features. The terrain is mostly rugged and steep. The Himalayas are of recent origin, one of the young mountain ranges, the soil structure is weak and of poor aggregation. On the whole the soil in various areas is light in texture and has low organic matter content. The general characteristic is of high erodibility. The Himalayan soils do not form a compact block but differ from valley to valley and slope to slope.

Faulty use of the principal resources, namely, soil, forests and water, has been primarily responsible for the widespread degradation evident in the Himalayas. The evidence of disturbing depletion of resources is briefly summarised below.

Owing to the sharp increase in population in recent decades, cultivation has been greatly extended, even in marginal land. Slopes of very high gradients are also being cultivated. Inadequate attention has been paid to correct agricultural practices, with the result that widespread erosion is being caused. It has been established that there are hardly any suitable soils left for agricultural use. Most agricultural land is in the lower categories of fertility. The loss in large areas may soon become irreversible. Protective measures have, therefore, become a matter of the utmost urgency.

Hoshiarpur siwaliks

The history of forestry and conservation on the east and west of the Yamuna river in Siwalik zone has been considerably different. On the east of the Yamuna river the forests were well protected in the 19th century, but this was generally not so to the west of the Yamuna. A typical case may be taken of the Hoshiarpur district in Punjab. On account of denudation, the perennial streams which ran between well defined banks became torrents, rising suddenly at the time of rain storms, and becoming dry in greater part of the year. There is serious loss of soil and of the fertility of arable lands, and the sand brought down by the torrents destroyed the fertility of the agricultural land below. In the Hoshiarpur district, the area occupied by the 'chos' beds at three successive intervals was as follows:

Year	*Area in ha*
1852	19,000
1897	36,000
1939	1,71,000

showing the great increase in the area laid waste, which is typical of other similar cases.

As far back as 1900, a *Chos* Act was enacted and enforced in Hoshiarpur and Ambala districts through the Civil authorities, sometimes assisted by Forest Officers, but no appreciable improvement took place. In 1928, Holland submitted a special report to the Punjab Government on the erosion position; in 1932 a special Committee of the Legislative Council presided over by Miles Irving, Financial Commissioner, was convened and came to the conclusion that the basic cause of erosion was the disappearance of the forests from the hills. In 1934, A.P.F. Hamilton was appointed Assistant to Deputy Commissioner, Hoshiarpur and Ambala, and was later placed on special duty to report on erosion in the Rawalpindi Division. In 1937, a Forest Commission again concluded that soil erosion was prevalent throughout the sub-montane tracts. The recommendations of this Commission were accepted by the then Punjab Government and a Soil Conservation Circle with seven divisions was constituted in 1939. In 1942, the *Chos* Act was extended to Kangra and in 1944 this Act was amended, improved and extended to the whole of the Punjab.

A definite turn in the tide appears from 1935, when through the entrusting of the work to the Forest Department and chiefly through the indefatigable efforts of Hamilton and Gorrie, a very useful start in soil conservation was made. The work consisted chiefly of closure to grazing and protection, substitution of grass cutting and stall feeding for promiscuous grazing, torrent training, land reclamation, contour terracing and embanking of whole catchment areas; through the help of public education campaigns, Land Reclamation Societies, and co-operation with Co-operative, Revenue, Agricultural and other Departments, encouraging results were obtained. Position has got worse in the affected areas in the post-independence era, but a World Bank aided scheme is now under implementation in Hoshiarpur district.

Western and central Himalayas

A major part of the Western and Central Himalayas suffers from serious soil erosion. Chandi Prasad Bhatt records one of the worst evidences of erosion, viz. the serious landslips and flooding in the Chamoli district caused by the unusually heavy rains of 1970, when floods inundated an area of 1,000 sq km, washed away six motor bridges, 10 km of motor roads and 24 buses, while large number of houses collapsed and sizeable standing paddy crops suffered. Further, the 75 year old natural rock-filled Gauna Lake, a mile long, half-a-mile wide and about 100 metres deep was levelled with silt, sand, stones and log debris. As a direct consequence of this a 10 km long stretch of the Ganga Canal from Hardwar to Patthani nearly 300 km from the flood source was choked up. It is worth noting that the canal is 180-200 ft in width and was filled with 5-8 ft of debris. It took six months and an expenditure of more than

Rs. 1 crore to clear the canal. During the blockage of the canal, *Kharif* crop in a million hectares of western Uttar Pradesh could not be irrigated, and the eight hydro-electric stations with the combined capacity of 48 MW on this canal went dead for six months. What is worse is that the floods seem to have become a more frequent feature in the Alaknanda and its tributaries after this year.

In another catastrophic incidence, a 10 sq km area of Pithoragarh district was crushed under massive landslides in 1977, which killed 45 people and more than 100 heads of cattle. On August 6, 1978, in another big landslide in the Gairaridhar catchment of the Bhagirathi river in Uttarkashi district, a big landslide occurred almost 4 km long and 1 km wide, creating two separate lakes in the Bhagirathi that eventually burst and destroyed a large number of villages. The Maneri-Bhali hydroelectric project sustained severe damage.

Due to inadequate forest protection, forest fires and heavy grazing the Dehra Dun and Saharanpur forests of Uttar Pradesh have been suffering seriously and results of the latest surveys have shown that the beds of Chos or Hill torrents are widening.

Dhauladhar project

Special mention may be made of the current Dhauladhar Project in Kangra, as a sequel to the success of the Indo-German Agricultural Projects comprising forestry, agriculture, animal husbandry and self-employment at an estimated cost of Rs. 10 crores over an eight-year period. The villagers are told to drastically reduce their cattle, feed them in hygienically designed sheds to improve their productivity and sell the surplus cattle to the Government. According to the Project Director, Ehrieh, heavy animal population—about 3.45 animals per person is one of the main reasons for vast denudation of the forests. The fodder and pasture improvement programmes envisaged under the project will encourage the villagers to take to stall-feeding the selected cattle. This would give better returns in the shape of milk products and organic manure. Some good results are already emerging.

As is well known, the Himalayas are a basic life support system, maintaining the climatic conditions, providing perennial water that irrigates the plains and containing tremendous untapped power potential. The mountain glaciers which provide a large quantity of water to snow-fed rivers have been receding. The glacier feeding the Ganga, it is reported, has presently receded to Gowmukh 17 km upstream of Gangotri.

On thousands of hectares of land, there is no longer any top soil at all, just a rocky substratum lacking organic matter or fertility. Forests are receding under the combined pressures of cultivators, uncontrolled herds of goats, sheep and cattle and wood gathering for home consumption or sale. In many areas, firewood is beyond the reach of village populations, so dung is burnt instead.

Statistics cannot capture the full magnitude of the tragedy, but they tell a dismal enough tale. According to Jha (1981), in Himachal Pradesh 38.5 per cent of the land area was covered with forests in the mid-fifties. Even this was much below the recommended ratio of 60 per cent. But recent information given by the Government reveals that in the last 25 years the forest cover of the State has fallen to 18 per cent. In other words, nearly one per cent of the land surface of the mountains and valleys of Himachal Pradesh is being stripped of its forest cover every year. Luckily; some important protective steps have been taken by the Himachal Pradesh Forest Department in 1982, when contractors' agency has been completely eliminated from forest fellings, and sale of petty demand timber and resin extraction in private areas have been made compulsory only through the Government Forest Corporation.

In general, man has been the principal agency and his impact has been felt through easily recognised routes; clearing, burning, grazing by livestock, terracing, plant introductions, abandonment due to the loss of soil or its fertility, soil compaction, severe erosion, landslides due to improvident land use and terrain destruction or modification and lopping to the stage of extinction in many places (notably of the banj and the other oaks). The landscape has been changed, sometimes, to human and environmental advantage, occasionally for benefit to one of them and often to the detriment of both. The extension of apple orchards and deodar plantations are at one extreme of desirable activities, whereas the loss of soil through potato cultivation across the slopes, landslides through the loss of vegetal cover, seepage caused by faulty road construction, on unstable terrain, surface quarrying, etc., are at the other extreme. There are a few primeval forests left, and scrub and grasslands have invaded the previous forest territory where it has not been put to organised human use for agriculture and settlement.

Pastoralism which has extinguished many civilisations in the past is playing havoc with its insidious and relentless march into the economies of mountain meadow lands too. It is but a remnant of millennia of old pre-agricultural domestication economics. It continues to be a potent force responsible for the continual degradation of agriculturally marginal resources, causing widespread devastation in the Himalayan belt.

Strategy of hill development

Following Seth, 1961, we may say that the most important strategy of hill development lies in the multi-dimensional use of the same parcel of land for forest products (major and minor), edible materials, pasture development and animal husbandry, combined with such subsidiary occupations as apiculture and silk-worm-rearing. The idea is to produce wood (both industrial and domestic) from the trees, fodder from their leaves and pods as well as from herbs, grasses and legumes cultivated on the forest floor, fruits and minor products from the trees (gums, resins, etc.) and pisciculture in the streams or lakes that may be found or created in that area. The area may be used for direct grazing on a system of periodical rotations and closures as well as for the production of cut fodder and silage. This procedure will enable the raising of prime-quality stock of animals for meat and hides, milk and dairy products, wood and fine-quality goat hair. It will be necessary to do the following:

1) Follow a policy of progressive and diversified yields as against single product sustained yields from the existing forests.

2) Open up hitherto inaccessible areas by creating the necessary infrastructure for multi-sectoral economic upliftment.

3) Increase land productivity by introducing high-yield combinations, making full use of species adaptability and potential and maintaining or increasing basal fertility by nutrient and ameliorative inputs.

Nomadic pastoralism cannot be eradicated, but has to be tamed and organised within its own mores. It is a way of life adapted to a condition of environment and there is no reason why a precarious but still achievable balance cannot be struck, with the deployment of relatively simple technologies, such as closures, rotations and fertilisation. The long-term economic benefits are incalculable but staggering, and although results may come up slowly, they will emerge surely. The need for more money, more opportunity, more jobs for a population which is bound to expand (unless smothered by its own growth) can be met, and the answer lies squarely in developing the land-trees concept within the ambit of provident resource use, benefitting from the advantages of modern technology and the climate of shared social responsibility.

North-eastern Himalayas

Against the total geographical area of about 19.25 m ha and the reporting area of 16.53 m ha of the Eastern Himalayan Region, forests occupy 48.5 per cent, the area sown is 5 per cent, while 44.9 per cent of the land is reported to be barren and unculturable, only 1.3 per cent of the land falls under all other categories. The details of forests by States and Union Territories are given in Table 6.5.

Table 6.5: North-eastern region—classification of forests percentage

State/Union Territory	Total forests ('000 ha)	Reserved forests	Protected forests	Forests under district councils/ individual ownership	Un-classified
Arunachal Pradesh	51,540	21.60	—	0.29	78.11
Assam	2,860.8	57.40	—	6.11	36.49
Manipur	1,515.4	9.04	27.52	—	63.44
Meghalaya	852.8	8.28	1.21	90.51	—
Mizoram	1,223.3	58.26	—	—	41.74
Nagaland	287.6	9.95	18.01	72.04	—
Tripura	601.1	65.58	34.42	—	—
Total	12,495.0	32.80	5.49	9.35	52.36

Against the total forest area of 12.4 m ha in the region, the reserved forests constitute 32.8 per cent, the protected forests constitute 5.5 per cent, forests under district councils or individual ownership are 9.35 per cent while the bulk of the forests, i.e. 52.36 per cent are unclassified forests.

Serious soil erosion is rampant in the North-eastern Himalayas, and is closely connected with the practice of shifting cultivation. This is widely followed by large number of other tribals also, especially in Orissa and is discussed elsewhere in this book (Chapter 11).

The Thar desert

The arid zone of India occupies an area of about 31.7 m ha of hot desert, in Rajasthan, Gujarat and Haryana, besides 10 m ha of cold desert in Ladakh, Lahaul and Spiti in the north. Out of the former, an area of about 18 m ha is the core of the desert especially in Bikaner, Jaisalmer, Barmer, Jodhpur, Nagaur, Churu, Pali and Jalor districts. The Rajasthan desert fulfils in a large measure, though not in a rigorous sense, the general characteristics of a desert, viz. low rainfall with a large variability, large diurnal temperature variation, high evaporation, non-existence of a perennial river, scanty vegetation, very little agriculture, dependence of man on animals and sparse and nomadic population.

Average annual rainfall of the region varies from 150 to 500 mm decreasing from east to west, with a coefficient of variation of 60 to 70 per cent. Most of the rainfall occurs erratically, from July to September. The mean daily maximum temperature in the summer is generally 40°C and during the winter varies from 22 to 28°C. The mean daily minimum temperature varies from 24 to 26°C during summer and 4 to 10°C during winter. The mean diurnal temperature variation ranges from 12 to 17°C. The mean relative humidity during the summer varies from 36 to 50 per cent, and from 66 to 78 per cent during the monsoon in the morning hours. In the afternoon, however, there is a drop and the mean values range from 20 to 35 per cent during summer and 48 to 60 per cent in the monsoon season. The mean evaporation during summer exceeds 10 mm per day. The potential evapotranspiration values during summer vary from 7 to 9 mm per day. The mean daily wind speed is recorded to be highest during summer and monsoon seasons being 8 to 20 km/hr.

The first rational approach to an understanding of the great Indian desert and its problems originated from the First Five Year Plan (1951). According to this, topographical surveys showed the spreading of the desert at the rate of 800 metres per year for the previous 50 years and its encroachment upon apporximately 13,000 ha of fertile land every year. Following this note of alarm, the National Institute of Sciences, India, arranged in 1952 a comprehensive seminar on Rajasthan desert, in which this particular situation was specially discussed from all possible angles. The principal finding of these deliberations was that the desert, as it presents itself now, is the result of meteorological, geological and hydrological changes over the centuries, for which evidences are not lacking, but the desertic condition has undoubtedly been accentuated by the activities of man. As pointed out by Mann, the notion that the Rajasthan desert has been advancing is fairly widespread, but lacks scientific unanimity, mostly because of terminological controversies. The increase and decrease in wind-blown surfaces have been illustrated by a comparison of old and recent survey maps which indicated an extension of the desert towards the east. However, the fact that in some areas sand formations have developed, whereas in others they have diminished or vanished is no conclusive proof of the movement of the desert. Recently, a study based on socio-economic parameters has also yielded evidence that there may not be any scientific basis for the view that the Rajasthan desert has been spreading in the north-easterly direction. Scientists are unanimous, however, with regard to the accentuation of xeric conditions within the desert owing to over-exploitation of the vegetation and land resources.

The major factors of desertification (accentuation of the desert condition) are the escalation of human and livestock population and their activities, besides the climatic and geomorphological factors. The human population within the Rajasthan desert increased from 3.42 m in 1901 to 8.84 m in 1971—a growth rate of 158 per cent, the corresponding rate in comparison for the whole of the Rajasthan State being 125 per cent.

The increasing human population is a serious stress, particularly on the vegetal resources of the desert. The seeds of grasses, e.g. *Panicum turgidum*, *P. antidotale*, *Cenchrus biflorus* and *Echinochloa colonum*, are mixed with millet for making chapatis (unleavened cakes) especially during drought years, as these are supposed to add to the nutritive value of the food. The intensity with which seed collection is made for direct human consumption throughout the desert region seriously affects the natural process of regeneration of the desirable plant species in the inhospitable terrain.

Livestock population far exceeds human population in arid western Rajasthan. It increased from 9.4 m in 1951 to 15.5 m in 1972. The goat and sheep populations ranged from 57.1 to 69.3 per cent during this period. Owing to continued droughts during 1967-71, with the consequent migration and mortality, the number of cattle fell heavily (10.8 per cent decrease), but the number of hardy animals, e.g. the goat, increased substantially (34 per cent). The data thus not only reveals a preponderance of the goat and sheep population in the arid Rajasthan, but also point to their increase during the years of drought. The goats are the desert-makers par excellence, eating every bit of green or dry vegetation.

Forests occupy only 2 per cent of the area although the extent of land classified under barren and culturable waste is 46 per cent, which could be planted with tree species like *Acacia tortilis* and *Prosopis juliflora*. A major factor aggravating the unfavourable consequences of aridity is that the area under grazing is dropping. It dropped from 13.09 to 11.04 m ha during 1951 to 1961 while the population of grazing animals increased from 9.4 m to 14.4 m during the same period. The same trend of diminishing area and rapidly expanding grazing population is persisting. Further, while most of the land in the area is fit only for forestry or range management, land is increasingly brought under cropping. The area cropped rose from 26 per cent in 1960 to 38 per cent in 1970, thus extending cultivation to submarginal areas.

It is estimated that about 60 per cent of the area is covered with blown sands, forming sand dune chains, and interdune sand sheet plains. Some of these dunes are stabilised and support some vegetative cover, some are bare with loose sands. Shifting dunes are common, advancing with prevailing south-west winds, and engulfing adjoining cultivated lands, roads and habitations.

Damage from wind erosion is of numerous types. The dust storms resulting therefrom are, to say the least, disagreeable and often almost unbearable. People in villages, towns and cities undergo serious illness from prolonged dust inhalation. Fences, ditches and channels are blocked or buried and farmsteads are rendered uninhabitable. Crop damage, particularly in the seedling stage, by blowing soil is often a major concern. Tender seedlings may be completely killed. Often, sufficient soil is removed to expose plant roots or ungerminated seed, and this results in crop failure. Covering of established crops by drifting soils is another common result. These are but a few of the more evident results of wind erosion. The most serious and significant by far, however, is the change in soil texture caused by wind erosion. Finer soil fractions (silt, clay and organic matter) are removed and carried away by the wind, leaving the coarser fractions behind. This sorting action not only removes the most important material from the standpoint of productivity and water retention but leaves a more sandy, and thus a more erodible soil than the original. Successive removals eventually create a soil condition wherein plant growth is minimised and erodibility greatly increased. Control becomes more and more difficult. In the extreme, the sand begins to drift and form unstable dunes which encroach on better surrounding lands. It is this degradation of soil resources that constitutes the most serious aspect of wind erosion. Uncontrolled, they become a menace to adjacent productive lands.

Central Arid Zone Research Institute

In a recent study on desertification, completed at the Central Arid Zone Research Institute, Jodhpur, on behalf of the UNESCO it has been found that about 9,290 km^2 or 4.35 per cent of the western Rajasthan has already been affected by the processes of desertification and 1,62,900 km^2 or 76.15 per cent of the area has been categorised as highly and moderately vulnerable to the various processes of desertification. The shifting of sand and soil erosion by winds are the majoı causative factors.

With the establishment of the Central Arid Zone Research

Institute at Jodhpur in 1959, and the gradual expansion of its activities spread over about 60 centres over the entire western area of Rajasthan, a number of successful technologies have been evolved and standardised. However, the available scientific information on the rational use of ecosystem resources is yet to be converted into action programmes. Some efforts to plan, organise and provide funds to improve desert environment need mention. In 1970-71 Government of India sponsored a Rural Works Programme in drought prone areas. A Desert Development programme was launched in 1977-78 for an integrated development of desert areas to increase productivity, income level and employment opportunities for the inhabitants, through optimal utilisation of physical, human, livestock and other biological resources. The Government of Rajasthan have established a Department of Afforestation and Pasture Development. The Rajasthan Canal Project which envisages transforming 11 per cent of the desert area into a vast greenery, envisages lining of branches, distributaries, minors and water courses, construction of roads, afforestation and pasture development and land shaping and land reclamation. As much as 89 per cent of the area would however remain under deteriorating environmental conditions at the mercy of increasing human population, overgrazing by livestock, erratic rainfall, frequent droughts and hot desert winds, unless drastic steps are taken to remedy the situation.

Ravines

Grim and spectacular evidence of soil erosion is afforded by the ravines of the Yamuna, the Chambal, the Mahi, the Sabarmati rivers and their tributaries, where villages once surrounded by fertile fields now lie in a network of ravines, considerable agricultural areas have been laid waste and on the verge of enormous ravines—the peasant fights an apparently losing battle against the forces of nature. There is no historical record to show when the deterioration started but it is reasonable to assume that indiscriminate use of land leading to disturbance of the ecology and environment has been one of the reasons for this degradation. Erratic, short duration and high intensity rainfall, loose and friable nature of the soil, steep slopes and undulating terrain, faulty agricultural practices, cutting of trees and bushes, grazing of lands and similar biotic interference have combined to aggravate the situation, ultimately resulting in deep gullies, commonly known as ravines. High flood level has contributed to the deepening and widening of the ravines. The rivers in high floods back up into the ravines, and hasten soil slipping. Prolonged inundation causes damage to protective vegetative cover. Ravine formation has damaged fertile cultivable lands along the river banks of the region. The process once started continues with increasing speed.

The Planning Commission published a study on survey and reclamation of ravines in India in 1965. In 1972, under the auspices of the Ministry of Home Affairs, Government of India, a Working Group reported on the ravine problems in the country and advised formulation of a Ravine Reclamation Programme. According to this Working Group, the area of ravines in four States—Uttar Pradesh, Madhya Pradesh, Rajasthan and Gujarat—in 1972 was as follows (Table 6.6)

Table 6.6: Area of ravines in States

State	(lakh ha)
Uttar Pradesh	12.30
Madhya Pradesh	6.83
Rajasthan	4.52
Gujarat	4.00
	27.65

The Report of the Working Group gives the districtwise and riverwise distribution of the ravine lands in Uttar Pradesh, Madhya Pradesh and Rajasthan. In Gujarat, the ravine affected lands lie in north, middle and south Gujarat and the districts affected are Baroda, Kaira, Sabarkantha, Banaskantha, Mehsana, Ahmedabad, Panchmahal, Broach, Surat and Bulsar. The ravine lands in Gujarat have been categorised on the basis of ownership, e.g. privately owned ravine lands (60 per cent), Panchayat gauchar land (21 per cent) and Government owned ravine lands (19 per cent).

According to a report by Divisional Forest Officer, Gwalior, the area of ravines in Morena and Bhind districts of Madhya Pradesh increased by 36 per cent during the years 1943-44 to 1975-76 as follows (Table 6.7)

Table 6.7: Increase in ravine land in Madhya Pradesh

Name of District	Area under ravines (in lakh ha)		
	1943-44	*1950-51*	*1975-76*
Morena	1.380	1.477	1.913
Bhind	0.903	0.864	1.194
Total for Chambal Division:	2.283	2.341	3.107

This report also classified ravines according to depth classes as given in Table 6.8 below:

Table 6.8: Classification of ravine land in Madhya Pradesh

Name of District	Ravine area (in lakh ha)				Total area
	D-1	D-2	D-3	D-4	
	(up to 1.5 metres depth)	(1.5 to 5 metres depth)	(5 to 10 metres depth)	(over 10 metres depth)	
Morena	0.421	0.746	0.382	0.364	1.913
Bhind	0.317	0.519	0.233	0.125	1.194
Total for Chambal Division	0.738	1.265	0.615	0.489	3.107

The ownership of government ravine areas in Morena and Bhind districts is reported as given in Table 6.9.

Table 6.9 shows that by far the majority of the ravine lands in the Morena district is under the control of the Revenue Department while in Bhind district, it is private. It has also been reported that as a result of the extension of the ravines, the Ambaha branch canal system under the Chambal

Table 6.9: Government ravine land in Madhya Pradesh

Name of District	Ravine area (in lakh ha)		Total ravine area
	Forest Dept.	Revenue Dept.	
Morena	0.118	1.795	1.913
Bhind	0.071	0.285	0.356
Total	0.189	2.080	2.269

Ayacut Development Authority was directly threatened in 1981 by the ravine formation, as can be seen on its Sabalgarh-Ambaha section.

Along with ravine formation there has been a lowering of the water table. It has been estimated that as the accumulated result of flooding and scouring, the bed of the Yamuna at Etawah in Uttar Pradesh has been lowered by 80 ft in the last five centuries, with a corresponding fall in the spring level; this is established by the old sugar mills in the Etawah trans-Yamuna area where water level is now far too low to admit of irrigation and also by the fact that in the fort of Shergadh near Auriya, the curb of the large well in use in 1550 is now 60 ft above mean flood level. The cold weather level of the river is often 120-200 ft below the surrounding country. The uneven and ghastly appearance of the ravines is chiefly due to the peculiar nature of the rock formation, consisting of the clayey soils with intercalated layers of *kankar*. On account of reckless fellings and heavy uncontrolled grazing, the vegetation completely disappeared and serious soil erosion with deep gully and ravine formation started, eating into the cultivated lands.

Accompanying the ravine formation and desiccation is the lowering of the sub-soil water level; in parts of Agra, Mathura and Etawah districts the fall was up to 24 metres within seven decades ending 1940, and similar fall was reported in Bhind and Morena districts, where the water level went down to 50-65 metres depth. Many wells were thrown out of use; between 1875 and 1931, the number of wells decreased from 62,600 to 47,300 in the Agra district, from 35,200 to 20,800 in the Mathura district and from 40,000 to 10,000 in the Etawah district. In most of these districts, serious decreases were noticed in the acreages under the agricultural crops—wheat, barley and gram and also in the twice cropped areas up to 1945. There is marked and quick deterioration of fertility of the land, destruction of pasturage and a chronic shortage of drinking water in entire ravine areas.

Ravine reclamation

The earlier efforts of ravine reclamation have been in the nature of (a) forest plantations of economic species, and (b) development of fuel and fodder reserves. Successful examples of these measures can be found in the 'Fisher Forests', Etawah (Uttar Pradesh) which were developed in the latter half of the nineteenth century. The afforestation of Gwalior ravines in the early twentieth century is another example. During the early plan periods, systematic research on soil and water conservation in ravine lands was emphasised. A chain of regional soil conservation research centres was established by the Central Government, three of them being located in the ravine areas at Agra (Uttar Pradesh), Kota (Rajasthan) and Vasad (Gujarat).

The strategy suggested for deeper ravines is that the plateau and top areas should be reclaimed for cultivation, making suitable soil conservation and water drainage arrangements on the fringes. Similarly the valleys of the ravines including raised areas are suitably levelled for cultivation. The slopes of the ravines are used for forest and fodder development. The suitable species of timber, fuel and fruit trees in use are *ber* (*Zizyphus spp.*), drum stick (*Moringa olifera*), *khair* (*Acacia catechu*), *sissoo* (*Dalbergia sissoo*), *siris* (*Albizzia lebbek*), etc. At the Soil Conservation Research Centre, Vasad, successful plantings of lemon and bamboo in *katar* lands have been possible.

The problem of ravines has assumed urgency, because they are fast spreading into cultivated lands. According to the National Commission on Agriculture Report (1976), at present hundreds of habitations and their valuable tablelands with marching ravines are taking a toll of about 8,000 ha of valuable agricultural land every year, costing nearly Rs. 4 crores. In view of the above, ravine reclamation should receive national priority and the investment should not be denied on account of narrow or unfavourable benefit-cost ratio, even if it were so.

It has been estimated that the production potential of ravine areas in Uttar Pradesh, Madhya Pradesh and Rajasthan alone would amount to 3 m tonnes of foodgrains annually, besides fruit, fodder, and wood. On a conservative estimate the country is losing a total output worth about Rs. 157 crores a year by failure to reclaim and develop the ravines. The above estimates of ravine lands are not based on systematic surveys and there is an urgent need to carry out standard surveys in these areas.

It is of utmost importance to subdue the effects of runoff in the watersheds of the various ravines. It is imperative to tackle the watershed beginning from the water divide line to the confluence of the ravine with the main river. Unless the whole of the watershed is treated including the ravines from the gully head to the bottom, isolated works would be in danger of being washed away and lead to no benefit. Land ownership boundaries and individual field boundaries would come in the way of scientific planning of ravine land reclamation. It is, therefore, necessary that land consolidation and settlement operations are simultaneously undertaken. Planning should be done without regard to property lines and the project executed keeping the interest of the area as a whole. The redistribution of the owned property may be done giving full consideration to various types of measures taken and the ultimately prepared benched and terraced cultivable lands. Areas considered suitable for horticultural purposes should similarly be planned on contours, and redistribution done in such a way as to cause minimum interference in the management of not only irrigation water but also in planning and controlling the runoff rain water. Even the areas unsuited for raising food and horticultural crops and recommended for forestry should be subject to runoff management.

During the years from the First Five Year Plan up to 1970-71, ravine afforestation was done over about 24,000 ha in Uttar Pradesh. The work done in Gujarat from the Third Plan to the end of the Fourth Plan consisted of reclaiming about 31,000 ha of ravine lands under agriculture and 18,500 ha of land under afforestation.

The cost of reclamation of ravine lands in Gujarat was estimated at about Rs. 1,900 per ha (1970-71), while in Uttar Pradesh including reclamation by mechanical means, the cost was estimated at Rs. 5,000 per ha, and through manual labour the cost was estimated at half this amount. Since the reclaimed land is valued many times more than the original ravine land, the reclamation is likely to be economical. During the years 1981 and 1982, aerial seeding of ravines, after ground soil working, with *babul* and *Prosopis juliflora* seed in particular has been attempted. Poverty is rampant in the area and has to be banished. Besides, the anti-social elements inhabiting the area and disturbing peaceful living in the neighbouring countryside require to be transformed into social beings, and peace in the region restored.

Indo-Gangetic and coastal plains

In most parts of the Indo-Gangetic valley and in the Coastal Plains, the differences of level are very small, and soil erosion very often is not a serious factor except locally. The cultivator in permanent settlements working on carefully levelled fields which have been in use for a very long time has in general learnt to conserve the soil well. However, sheet erosion, acute water shortage, recurring droughts, ill drained soils, improper technology, shortage of fodder and fuel are often sizeable problems. In the coastal areas as recorded by the National Commission on Agriculture, the area under coastal sand dunes is, in places, on the increase and the blown sand causes serious damage to the standing crops in its neighbourhood. In some places *Casuarina* has been planted by the Forest Department on the shores backed by coconuts, etc., and this has effectively controlled the blowing sands as in parts of Orissa and Tamil Nadu. Such plantations need to be extensively taken up in the coastal areas. Shelter belts can help a great deal in the Indo-Gangetic Valley to stop or reduce wind erosion.

Chhota Nagpur plateau

Destruction of forests with denudation, serious soil erosion and mismanagement of land are common features of the Chhota Nagpur plateau, Santhal Parganas and the uplands of Western Bengal. The former two consist of broken plateau land

and mountain spurs, being the termination of Satpura Hills and the undulating districts of the West Bengal form a connecting link between the plateau and the alluvial plains of Bengal.

The Chhota Nagpur tract contained extensive private forests in the first half of the century, which were ill managed and were regularly subjected to destruction. In Ranchi district the area of forests showed a decline of 14 per cent in the 30 years from 1902 to 1932 according to Settlement Reports. Denudation of forests was serious in Manbhum district and also in Palamau, Hazaribagh and Singhbhum districts. Cultivation was often extended up to the slopes of the hills. The main rivers of the tract are Sabernarekha, Kasai, Silai, Darakeshwar, Damodar, Ajoy and Mor, and besides these there are countless *khals* and smaller streams. The smaller rivers and streams practically dry up in hot weather, when even the larger ones are reduced to trickles through wastes of sand; after heavy rains the waters rise with extraordinary rapidity and become formidable torrents, 'the rivers flowing red and thick with mud and silt'. The floods of the Damodar were the cause of great misery and suffering to the people of West Bengal.

In 1908 following the Stephenson Committee Report, a Bill to control private forests in Bihar was proposed but dropped. Another Bill came before the Bihar Legislature in 1925 and met the same fate. The partial and half-hearted methods of control of the private forests by Bihar between 1930 to 1944 did not prove of much avail. The Bengal Private Forest Act, 1945 and the Bihar Private Forest Act, 1946 were then enacted and enforced. Following the abolition of zamindari all over the country, all the private forests were vested in the State and a major long term improvement was made. Despite this, soil erosion is a serious factor over many parts of Chhota Nagpur. Following the construction of various dams on the Damodar and other rivers, the flood problems of the Damodar have been considerably resolved.

Wandering rivers

Due to major forces of erosion and siltation, great changes have taken place in the topography of western India within comparatively recent geological times. Apart from the Rann, which was a gulf of sea till much after Alexander's invasion, and where a submergence of complementary uplift took place as late as 1819 A.D., the Indus basin and the Rajasthan have witnessed remarkable changes in drainage which it is necessary to consider. There are many conflicting views but the following seems to have been the probable course of events.

The Indus itself has only two fixed points in its course through the plains and has been changing its channel frequently. It might originally have even been confluent with the Ganges. The highest elevation of the Sirhind watershed between the Indus and Ganges is only 924 ft above M.S.L. and a trifling change in the surface might turn the effluents of one river into the other.

Indus has shifted its lower reaches by 160 km westwards and no longer empties itself into the Rann of Kutch, as it did at the time of Alexander. It deserted its old course at Arur about 962 A.D. Through the deltaic flats may still be seen the old channels which conducted its waters to the Rann.

The streams making for Rajputana across the low watershed converge towards a large dry water course (Ghaggar) which runs parallel to the Sutlej and was fed by its waters. In its lower reaches (Hakra), it was probably fed by the Indus in the eighth century A.D., the lower channel coinciding with the eastern Nara in Sind. This, however, is doubtful as the eastern Nara runs through a series of swamps which should have been filled up long since by deposits, if a great river had followed this course. The Beas did not join the Indus either, but probably followed a distinct course to the Indus. It now joins the Sutlej due to westering of the latter. The confluence of the two has also probably shifted 245 km up from Bahawalpur to above Ferozepur. The Ravi and Chenab had their confluence near Multan at the time of Timur's invasion in 1398 A.D. but it has now shifted 30 miles up. However, the most remarkable case is that of the Saraswati, which was a considerable river known to the Vedic Aryans and probably still followed its old course in the sixth century B.C. Now, it is a minor stream between the Sutlej and the Yamuna, which joins the Ghaggar whose waters are engulfed by the sands at Bikaner.

According to some traditions, it followed an independent course to the sea but this is doubtful as there is no suitable stretch of low country between the Aravalli hills and the eastern Nara to permit a river to flow to the Rann. Another view is that it joined the Sutlej near Suratgarh when the latter followed its old Ghagger course, and then flowed independently to the sea under various names like Hakra, Sotra, Wahind, the lower portion of the channel coinciding with eastern Nara, which was also perhaps a distributary of the Indus. However, it may be, that in course of time the siltation of Saraswati's channel either through its own deposits swollen by deforestation in its upper catchments or by the accumulating sand of Rajasthan or both, caused its waters to flow eastwards into the Yamuna (which was cutting into its deposits), which merged into the Ganges at Allahabad. The volume of the Saraswati may also have diminished by a decrease in rainfall or because of deforestation on the lower Himalayan slopes or both. This view may account for the ancient Indian tradition of three rivers, Saraswati, Yamuna and Ganges meeting at Triveni (Allahabad).

Thus the Saraswati had disappeared in early centuries of the Christian era, the Sutlej was no longer independent of the Indus in the early years of A.D., and by 1790 A.D. the Hakra was dead. The westering of the Indus and northering of Sutlej have resulted in the Indus basin being permanently separated from the Peninsula by vast desert spaces, in which traces of ancient river beds testify to its once fertile nature. Thus has the Indian desert accomplished its march.

Another incidence may be quoted in the Kosi river which has been called the sorrow of Bihar. The main stream of the Kosi river rises from Nepal and it has two important tributaries—Tamur and Arun, the former rising from Kanchenjunga, and the latter from Tibet and Everest. On account of the enormous charge of debris, Kosi has been continually changing its course for several hundred years. It is believed that at one time it flowed into the Brahmaputra, later to the east into the Ganges, but says Inglis it is certain that it flowed into the Mahanadi. Since then it occupied a series of beds ever westering. In 1738, it was near Purnea; in 50 years up to 1946 it moved westward at an average rate of 1.6 km a year not steadily, but in a series of swoops, having for example moved 19 km in 1934-36. After India got independence, a protective embankment has been constructed on both sides of the Kosi river, but whether, in the absence of adequate treatment of the catchments, the embankment can long be effective is a moot question.

Deccan Plateau—Eastern and Western Ghats

The Deccan Plateau is on the whole much more stable than the Himalayas and soil erosion is a factor of somewhat lower importance in this area. Despite this, many areas have been deforested and hillsides have been laid bare, exposed to naked rocks as in Sahyadri hills in the Poona District. Soil conservation works were taken up on a large scale by the erstwhile Bombay State on the basis of a statute in the Land Improvement Schemes Act 1942. Till 1950, Maharashtra State did pioneering work on a big scale not only on problems of soil erosion and methods of conservation, but also on extension of conservation measures on cultivated lands.

In many dry areas of the Deccan Plateau, land is very undulating as a result of erosion of different kinds over a long period of time. Consolidation of landholdings and land levelling is essential in such places, combined with afforestation in selected areas.

Soil surveys and progress of soil conservation works

The All-India Soil and Land Use Survey Organisation (AISLUS) through its three old regional sub-centres and a zonal centre at Hyderabad has carried out large-scale soil surveys. The Soil Resources Inventory Centre was merged during the Fourth Five Year Plan with the AISLUS. Besides priority delineation of small watersheds and detailed soil surveys in selected priority watersheds in 37 catchments of river valley projects and flood prone rivers, the AISLUS completed priority delineation surveys in 3.72 m ha and detailed surveys over 2.79 m ha. A remote sensing centre for agricultural development has been established in 1981 in collaboration with UNDP/FAO for application of modern remote sensing techniques in soil and land resources assessment, monitoring of land degradation and related aspects. Till 1980-81 about 200 soil survey reports were issued besides preparing compilation of soil hydrologic grouping of about 425 soil series and five class site suitability classification for afforestation and pasture development.

Soil conservation works have been implemented under Central and State Sector Schemes on an area of 24.4 m ha in India till 1980-81 under various treatments of soil and water conservation measures, incurring an expenditure of about Rs. 748 crores. Bulk of the programme was taken up by the various State Governments as State sector activity. Centrally sponsored and central sector programmes functioned as a kind of pilot work. Out of the 79 m ha of the catchment areas of 31 river valley catchments, about 23.8 m ha have so far been identified as problem areas and calling for earliest treatment. Since the Third Five Year Plan when work in these areas was started till the end of 1980-81, about 1.5 lakh ha of land comprising of agricultural, forests and other lands have been covered at an expenditure of Rs. 105 crores. Following the setting up of the soil conservation board at the Centre in 1952, soil conservation boards have been gradually formed in various States and Union Territories, and are helping to co-ordinate the relevant activities to some extent.

Although analysis of available sedimentation data has shown that in some cases, e.g. Bhakra, Damodar and Barakar, perceptible decrease in the reservoir sedimentation has taken place with the increase in the coverage of area by soil and water conservation treatment, the destruction of forests on the whole, the increase of cattle population with indiscriminate grazing, and the faulty agricultural practices have been and are such major negative factors that perhaps soil erosion has continued to increase in the country on the whole.

Animal policy

A major cause of soil erosion in most tracts in India is the large cattle and other animal population in the country. Pastures as they exist in Western Europe are practically unknown in India. Stall feeding in India is very limited, and indiscriminate grazing is extensively practised. With ill-fed cattle frittering away their energies in roaming round, milk, meat and wool yields per animal are minimal. Excessive grazing and trampling of soil and retrogression or destruction of vegetation bring in rampant soil erosion, siltation of streams and rivers and floods.

India has the highest cattle and buffalo population compared to any other country in the world—about 236 m in 1972, part of it unproductive, despite the fact that bullocks are the main source of power in agriculture for cultivation and transport. A little over 70 m of these are milch animals. The average annual milk yield per cow is 500 kg, very low compared to the average of over 3,000 kg in the advanced countries. The reason for this is poor nutrition. The availability of green fodder in India is estimated to be one-fourth of the total requirement. Grazing lands constitute less than 5 per cent of the total geographical area. These are over-grazed. Forage conservation to provide nutrition in the off-season is almost absent. Cattle, therefore, live mostly on crop residues and sparse vegetation from wastelands. New-born calves consequently suffer through starvation or gross neglect. The survival of young calves is precarious. It is estimated that out of 100 newly born calves, only 70 survive the first year of their life, 49 the second year and 35 the third year to reach maturity. Reduction in the number of cows will also enable the young calves to be better fed and reach maturity in larger numbers. According to estimates, beef exports could be the largest single foreign exchange earner for India. The yield is expected to be Rs. 700 crores per annum—more than the export earnings from jute, tea, textiles and marine products put together. There is a world shortage of beef and European and West Asian markets could use an enormous quantity of beef from India.

The real obstacle to reduction in number of cattle is the ban on cow slaughter. It is unfortunate that demands are frequently made by such respected leaders as the late Acharya Vinobha Bhave, and Jagat Guru Sankaracharya of Sringeri Mutt for a total ban on cow slaughter. Such demands are altogether irrational and contrary to the national interests.

Says Article 48 of the Indian Constitution: The State shall endeavour to organise agriculture and animal husbandry on modern and scientific lines and in particular take steps for preserving and improving the breeds and prohibiting the slaughter of cows and other milch and draught cattle. Consequently, almost all the States have enacted laws for the prevention of cow slaughter. Only in Kerala it is permitted. In Maharashtra those cows which have stopped yielding milk are slaughtered. Before independence, about 50 per cent of cows were slaughtered and 50 per cent died as a matter of course. The present cow-slaughter rate is around 5 per cent indicating a huge waste of our cattle wealth.

India's current adult cow population is placed around 57 m of which only 25 m are in milk. The existence of a huge uneconomic and almost useless cow population is a serious economic liability. Says the Gokhale Institute: "The gradually diminishing role of bullocks as power in Indian agriculture, a singularly unproductive cow and a legal prohibition or social inhibition against the slaughter of the cow and her progeny are responsible for the present size, composition and physical condition of the Indian cattle population."

V.M. Dandekar in his book *The Cattle Economy of India* has made careful analysis of the problem of cow slaughter in a fearless and objective way. He suggests that cow-slaughter should be regularised so that a legitimate economic use of the animal is brought within the purview of the production function, and the farmer is given a choice whereby he may put in resources to their several alternative uses. As Dandekar emphasises it is strange but true that we do not feed the cow unless she promises milk, but we do not kill her either, we let her starve to death. Surely, religion cannot sanction starvation of cattle in preference to killing them, and starvation cannot be more humane or more in consonance with our cultural heritage than the slaughter of animals.

When an animal starves it nevertheless eats something and denies that much to other animals. It means that all animals are forced to starve, albeit in varying degrees. Starvation as pointed out by Dandekar cannot be equally selective also in the sense that those which survive starvation are not necessarily those which should survive. Moreover, a well-fed animal when deliberately slaughtered has high economic value. But, when a starved animal dies, it leaves behind little except bones and inferior hide.

Besides beef, a slaughtered cow makes available several by-products like tallow, lard, glands, tail stumps, blood, hides and skin, bones, horns and hoofs. These can be used for the production of consumer goods such as stearine, oleo-margarine, casing, guts, pharmaceutical products, animal and poultry feed and fertiliser. The animals' blood is used as a manure, a variety of products is also prepared from the blood for use in medicine and industry. It contains over 13 per cent nitrogen which makes it an important ingredient in fertiliser production. Blood meal has good export potential too.

Hides and skins are the principal inputs in tanning and in the leather finishing industry. India is one of the largest leather exporters in the world and has a 16 per cent share in world leather exports. It is the country's second largest foreign-exchange earner. There is, however, an acute shortage of hides and skins in India as a result of which even some hides are imported. *Prima facie*, Article 48 of the Indian Constitution should be amended to permit slaughter of cows which have stopped yielding milk.

In other countries, intensive sheep and cattle farming, using much less land and housing the sheep and the cattle for much of the year is accelerating the abandonment of grazing lands which are being taken over by forestry. Methods have been evolved to reduce the food consumption of animals by feeding them with grain sized plastic tablets which once eaten by the animal lodge in its stomach and thereafter take the place of ruffage, reducing the animals' need for hay.

As has been pointed out by the NCA (1976) also, the number of cattle and buffaloes in India has greatly increased since 1951, without corresponding increase in the feed and fodder availability. As the Commission reports say, "the vicious circle causing degeneration in the quality of cattle identified by the Royal Commission on Agriculture has been perpetuated". The goat population in India in 1951 was 47 m and rose to 68 m in 1972. As the NCA report says, "the trend of increase in goat population particularly in the desert areas is disturbing. This can produce a devastating effect on vegetation due to browsing habits of goats". The report goes on to say that at the present rate of growth, the number of goats was/is likely to be of the order of 74, 78 and 90 m in the years 1980, 1985 and 2000 respectively. The NCA recommended that the slaughter of goats for meat purposes should be increased so that the rate of growth of their population may come down to the level of 67 m by 1985 and gets stabilised at about 40 m by 2000 A.D. Needless to say that at present, the goats are the worst agents of extension of wastelands and steps are necessary to implement the NCA recommendations regarding the goat population, despite the fact that the goat is a poor man's cow.

Goat, however, is a prolific breeder and goat rearing can be a very useful profession for large number of rural poor, consistent with environmental conservation, if suitable trees for use as goat fodder could be grown on extensive wastelands and goats strictly stall fed.

Aggressive weeds

A major adverse factor of environmental land use is the spread of aggressive exotic plants link Lantana which have extended their domain during the last 50 years or so and now cover large areas in many parts of the country in forests and outside. Although no reliable surveys are available it is surmised that Lantana which was brought to India as a garden plant in the 19th century today covers 20-25 m ha of land in forests and outside. In one respect Lantana has served a useful purpose, i.e., in checking soil erosion and in stabilising undulating tracts. The stem and the spreading branches also provide some kind of firewood. It is worth noting that the plant spreads through birds who eat the fruits and eject the seeds with their excreta wherever they fly. *Prima facie* soil erosion could be extensively and cheaply checked by aerial spraying of Lantana seeds over affected areas. In terms of economic values, however, it would be a serious mistake to do so as such soils are practically lost for forage and other productive uses. Eradication of Lantana, incidentally is an extremely costly and difficult process. Another weed which has spread widely in many parts of the country during the last 20 years is Parthenium. It occupies large parts of Maharashtra, Karnataka and other parts, and came to India with the imported wheat. Close to Poona, today, Parthenium occupies practically all field bunds and vacant lands, tends to attack the agricultural fields and is a serious curse. The Vice-Chancellor of an agricultural university in Maharashtra expressed the opinion that all colleges and schools be closed for two months before the Parthenium flowers and help of boys and girls taken in eradicating Parthenium. The spread of pernicious weeds needs to be further closely watched and prevented.

Floods

Flood is defined as "a relatively high flow or stage in a river, markedly higher than the usual; also the inundation of low land which may result therefrom. A body of water, rising, swelling and over-flowing land not usually thus covered. Also deluge; a freshet".

Floods occur due to a variety of causes in almost all river basins. The term floods covers mainly the following situations:

a) Streams carrying flows in excess of the transporting capacity within their banks, thus overflowing adjoining lands.

b) Backing up of waters in tributaries at their outfalls into the main river with or without synchronisation of peak floods in them.

c) Heavy rainfall synchronising with river spills.

d) Ice jams or landslides blocking stream courses resulting in the backwater overflowing river banks.

e) Synchronisation of upland floods with high tides.

f) Heavy local rainfall.

g) Typhoons and cyclones.

h) Inadequate drainage to carry away surface water with the desired quickness.

Floods have been the cause of increasing damage and misery in India during the last 80 years. While discussing the subject of soil denudation as an adverse factor in river supplies and agriculture, the Central Board of Irrigation for India at their annual meeting in 1931 recorded their considered opinion that during the period 1915-30, "many of the largest rivers in India had exceeded their previous recorded floods, though on the information available this could not definitely be attributed to denudation in the catchments". Since then the Board increasingly realised the dangers of denudation in India. In 1937 they drew attention to the possible dangerous effects of deforestation on irrigation in India due to increase of the intensity of floods and the decrease of the dry weather flow in rivers, and said that "these detrimental effects have already been noticed in some of the smaller river basins, and though there is no absolute proof of the larger rivers yet having been affected, India cannot afford to neglect experience of other countries".

In 1938, the Board at the Annual meeting passed the following resolution:

"The Board is convinced that the evils of denudation in India are so serious and widespread that action for its further prevention should be taken without further delay. Denudation causes high floods in summer, and low river levels, and small supplies in winter, which result in the following:

1) Damage to canal systems through interference with the regularity of canal supplies.

2) Harmful deposits of sand.

3) Interference with river navigation.

4) Widespread damage to the country side."

During the period 1938-46, the Central Board for Irrigation for India repeatedly emphasised the importance of the subject and drew the attention of the Government of India to it. Inglis, the Director of the Central Irrigation and Hydrodynamic Research Station, Poona, has shown that flooding of the countryside adjoining alluvial rivers results primarily from the building up of the bed caused by excess bed material moving down the rivers. Work carried at Poona clearly demonstrated that meandering of alluvial rivers is entirely due to the material moving down the river exceeding what can be carried by the discharge with the slope available. "If the sand washed down from the hills could be sufficiently reduced, the rivers would begin to scour and lower their beds, and it would be possible to stabilise the river channels and maintain them in that condition."

The National Floods Commission

Considering the increasing gravity of the problem, Government of India appointed a National Commission on Floods in 1976 under the Chairmanship of Jaişukhlal Hathi which submitted its report in 1980. The report graphically analyses the increasing damage due to floods and the cost of the same. The average and maximum area affected by floods during the years 1953-78 is given in Table 6.10.

The damage at current prices during the different periods is given in Table 6.11.

It has been known, as has also been pointed out by the Sixth Finance Commission for India that there is a tendency on the part of the States to report unduly higher damage figures. Another factor obviously is the large increase in prices. The

Table 6.10: Area affected by floods (in lakh ha)

Period	Total area	
	Average	Maximum
1953-63	59.6	111.7
1966-70	75.1	95.4
1971-75	91.1	137.2
1976-78	175.7	178.9

Table 6.11: Damage due to floods

Years	Estimated damage (Rs. crores)
1953-61	449.53
1961-66	271.18
1966-69	404.71
1969-74	1,979.40
1974-78	3,128.47

damage during the different periods at constant prices is given in Table 6.12 below.

Table 6.12: Damage due to floods at constant prices

Five-year average	Total damages (Rs. crores)	
	at current prices	at constant prices
1953-57	60.86	63.45
1968-72	322.60	137.76
1974-78	845.13	207.43

Causes of floods

As accepted by the high level Committee on Floods, 1957: Flood problems arise not so much due to excessive discharge in rivers as due to excessive sediment load in them. Rain water soaks into the soil and mature forests amongst all natural vegetative covers have the highest rate of infiltration among different land uses. The seeps and springs are also regular features of subsurface and ground flow. Such underground flows are of low velocities and extend over months after the rains. With a well managed watershed, spring flows become continuous throughout the year. Rivers rising in the Himalayas derive their flows from both rainfall and snow melt; while snow melt contributes a significant proportion of the total annual flow, it has not so far been possible to assess its contribution to floods. Compared to the Himalayan rivers, the Central Indian and Peninsular rivers derive their flows from rainfall only and therefore most of them are seasonal with very little flow in non-monsoon season. These rivers by and large are stable, carry less sediment and cause less flood problems. While the Himalayan rivers tend to be perennial, the Peninsular rivers are seasonal with negligible flows in the fair season. For example, while the maximum flood in both the Ganga at Farakka and the Narmada at Gardeshwar is of the order of 70,000 cumecs, the minimum flows are about 1,100 and 30 cumecs respectively.

Floods originate in the watersheds of rivers in the mountains and the plains. The rainfall on the hillsides flows down the slopes at great speed unless retarded. As the sheet flow gathers momentum, erosion sets in and soil is washed down, resulting in loss of productivity of land and increase in the sediment content in the streams. Vegetation in the form of forests or plantations acts as a retardant of the sheet flow. Forests also provide leaf cover which breaks the impact of the falling rain and reduces erosion. Roots of trees create conditions in the soil texture which are conducive to percolation. Thus, in areas under vegetal cover, soil erosion is reduced and low floods are moderated. Per contra, deforestation and lack of soil conservation and watershed management are causes contributory to flash floods and soil erosion.

As stated earlier, the soil mantle in the Himalayan watersheds is friable and unless there is enough vegetal cover, the soil is easily eroded and the rivers get clogged. Earthquakes, landslides, shifting cultivation, road building and such other phenomena and human activities also result in increased erosion and sediment load in river courses. The Central Indian and Peninsular rivers rise and flow through areas which are geologically more stable. The sediment load in these rivers is comparatively small as a result of which they are less wayward.

Overspilling can also occur due to obstruction in or sedimentation of the river bed. The former situation arose in the Brahmaputra river after the earthquake of 1950 which caused extensive landslides and upheavals of land. Similarly, the beds of a number of streams in Assam have also silted up resulting in river courses being higher than the general valley floors on the flanks.

The annual flood damages in the Gange basin States account for about 60 per cent of the total flood damage in the country. The Ganga has a large number of tributaries, the important ones being the Yamuna, the Sone, the Ghaghra, the Gandak and the Kosi. They cover partially or fully, the States of Himachal Pradesh, Haryana, Rajasthan, Madhya Pradesh, Uttar Pradesh, Bihar, West Bengal, and the Union Territory of Delhi.

The northern tributaries of the Ganga rising in the hills, some in Nepal, cause most of the flood problems on account of the heavy flows and sediment they bring down from the Himalayas. Flooding takes place mainly in Uttar Pradesh, Bihar and West Bengal.

In Central India and Deccan region, the important rivers are the Narmada, the Tapti, the Mahanadi, the Godavari, the Krishna and the Kaveri. These rivers, by and large, have well-defined and stable courses and usually adequate bankful capacity. These rivers fully or partially cover the States of Madhya Pradesh, Gujarat, Maharashtra, Orissa, Karnataka, Tamil Nadu, Kerala and Andhra Pradesh.

Some measures to control floods have been taken during the last 30 years by making embankments, by raising the level of villages and by other methods. State and Central Flood Control Boards have been constituted. A sum of Rs. 700 crores has been spent on flood control measures thus rendering reasonable protection to 10 m ha of land. However, the area requiring further attention now aggregates to 32 m ha. The National Commission on Floods fully recognised the evil effects of deforestation and degradation of land, and listed six major factors which contribute to the high rate of runoff and sediment discharge from the upper catchments of the rivers mainly in the Himalayas. These are, as outlined by the Commission—(a) shifting cultivation, (b) grazing, (c) people's rights and privileges, (d) forest fires, (e) surface mining, and (f) landslides and slips.

The Flood Commission also recorded their views that people's rights and privileges on forest land have constrained proper management of protected and unclassed forests. The grazing principles and extension of trees to vacant land remain largely unfulfilled. The target of obtaining at least 60 per cent of land under forest as a check on erosion in the mountainous regions has not also been fulfilled.

The Commission endorsed the recommendations made by the National Commission on Agriculture relating to the forest land and emphasised the development approach on priority basis for the upper catchments of the flood-prone rivers in particular. Recognising the difficulties experienced in establishing plantations on the highly arid hill slopes of the Himalayan region, the Commission specially recommended that under the existing legal provisions, large-scale closure to grazing in such areas should be enforced and measures to develop them as low or high altitude grassland should be taken up.

CHAPTER 7

Some Forest Management Concepts

Basic concepts

This Chapter discusses certain essential concepts of Forest Management, specially concerning production, which are universally accepted. Any forest consists of a large number of trees. Each tree represents a certain volume of wood. Methods of measuring height and volume of trees have been developed. Each tree also puts on a certain increment each year. An acre or a hectare of forest would usually consist of trees of different species and sizes. Standard methods have been developed to calculate volumes of different tree species and crops.

Volume tables

Volume tables show for a given species the average contents of trees or logs for given dimensions. The given dimension may be timber at breast height alone, timber at breast height and height of the tree, or timber at breast height, height of the tree and some measure of form or taper. Volume tables may be general, regional or local, depending upon the scope of their applicability. Volume tables may be commercial in which the contents are given as volume measured up to a thin end diameter down to which conversion is usually done, omitting the stump volume. Alternatively, volume tables may be standard, i.e. in which the contents are given as a volume measured down to the limits of standard timber and if necessary small wood with stump included.

Yield tables

Besides volume tables, yield tables are important for crops. Yield tables give the standing volume of a crop plus the total volume removed in thinnings, since its establishment as a more or less even aged stand or the sum of the final and intermediate yields. Yield tables are usually in the form of a tabular statement which summarises in hectares or other unit area based on all the essential data relating to the development of a fully stocked and regularly thinned even aged crop at periodic intervals, covering the greater part of the life of a tree.

Forest growing stocks and increments

Then there is the concept of forest growing stocks. As most of the forests are comparatively mixed, some idea should be formed of the total growing stock in volume per acre or hectare for different species. Similarly, the question of the increment being put on for such forests per hectare by different species is equally important. The growth of different species of trees varies with age, and is an important subject of study. The increase in volume is faster to start with, but gradually tapers off, after a certain age, as the tree gets older, as the following curve shows:

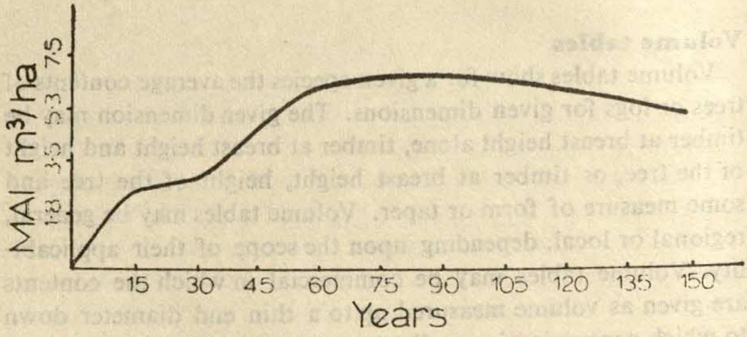

Fig. 7.1. Increase in volume of tree with age-sal quality II/III

Rotation and value increment

Standard methods have been developed to find out the optimum rotation at which a tree crop should be worked for maximum profit. As is well-known different species of trees have different values in the market according to their utility. This brings us to the question of value increment for a tree. It would be seen that value increment would seem to be most crucial in economic forest management.

Demand and supply

Besides timber and fuel, forests supply various other forest products, namely bamboos, resins, fruits, leaves like tendu leaves, medicinal plants, etc. The question of demand and supply is naturally vital and important. Forest management envisages optimum return on the capital consistent with meeting the national requirements at reasonable prices. In India in particular, forests are almost entirely under Government control. This envisages supply of forest products at reasonable rates to meet the public requirements.

Site management

The most important object of forest management is to maintain and improve site quality. In some cases, forests are maintained merely for physical protection of the soil and the site. This is so, specially where the terrain is steep or very steep or the soil is liable to erosion. Apart from such areas forests are managed to yield optimum yield of forest products. In such cases it is vital that forest management should aim at least on sustained yield of forest products, and in fact increasing yield of such products. We have also the concept of normal forests. A normal forest is defined as a forest which for a given site or given objects of management is ideally constituted with regard to growing stock, age class distribution and increment, and from which the annual or periodic removal of produce equal to the increment can be continued to be taken out indefinitely without endangering future yields. It serves as a standard with which to compare an actual forest so as to bring out latter's deficiencies for sustained yield management. It can be considered as one in which (i) trees of all sizes, classes, or crops of all age classes are present in correct proportion, to permit continued removal of an equal volume of exploitable stems without affecting future yields, (ii) each tree crop is putting on normal increment, and (iii) no silvicultural or other obstacles exist to the continuance of felling of exploitable stems.

When age gradations or age classes are arranged normally and put on normal increment then the forest is said to contain a normal growing stock.

Normal increment

The maximum growth put on by each age gradation, given a certain species, locality and rotation, and optimum conditions of growth is equal to normal increment. This is the increment attainable by fully stocked stand or a series of fully stocked stands arranged in a normal distribution of age classes for a given species, locality and rotation. To obtain normal increment is the goal of silvicultural practice.

Abnormal forests

Forests are abnormal when they are over-stocked, i.e. volume per unit area is more than normal, e.g. in over-mature forests or more areas under older age gradations or age classes. Forests are also abnormal when they are under-stocked, i.e. when the volume per unit area is less than normal, namely with preponderance of younger age classes. Forests are also abnormal when the volume is normal but the age gradations or age classes are abnormal, e.g. forests composed of same age gradations or classes.

Forest regeneration

Sound forest management ensures adequate regeneration of forests all the time. Regeneration may be by seed or by coppice. Regeneration may be obtained by natural methods, or by practices analogous to horticulture, i.e. by clearing an area and planting. Forests are managed under the uniform or the selection system. The uniform system envisages distribution of different age classes in different areas, while under the selection system it is envisaged that all age classes would be present practically in every hectare of forest. In general, the selection system is considered somewhat superior to the uniform system as it makes better use of the site conditions.

Artificial versus natural regeneration

The relative merits of artificial and natural regeneration need to be considered. The chief claims made for natural regeneration are: (1) minimising the exposure of the soil; (2) economy of labour; (3) flexibility permitting of great extension of the regeneration area in good seedling years and of obtaining regeneration in advance of fellings; (4) genetic improvement through the survival of only the most vigorous seedlings out of large numbers; (5) reduced risk of damage from natural causes including pests and diseases; (6) maintenance of natural mixed type; and (7) lower costs. The opposing claims in favour of artificial regeneration are: (1) quicker results; (2) full and even stocking; (3) facility with which species composition can be regulated; (4) concentration of all phases of forest work, reducing costs and facilitating supervision; (5) more rapid early growth and so less risk from weeds, browsing and other dangers and (6) in the long run, a better return for the financial outlay even when the actual operation is not cheaper.

In general terms it may be said that natural regeneration should be preferred to artificial wherever it can be done with a reasonable expedition, certainty and cost. However, if the operations are liable to be drawn out, and include a considerable proportion of failure, then artificial regeneration should be preferred. Modern conditions place increasing emphasis on concentration of work for various reasons—easier supervision of increasingly large areas, easier conditions for mechanisation and application of measures against pests, cheaper extraction and more and more regular employment. Although natural regeneration is relied upon in India in some places, by far in larger areas the existing conditions are such that artificial regeneration has to be increasingly employed.

Forestry as major public sector undertaking

As is well known, forestry in India is perhaps the biggest and most widely dispersed public sector undertaking in the country, more specially in backward areas and in areas with poorer communications, compared to agriculture in which ownership vests with say 100 million individuals or more, and therefore, the incentives are altogether of a different nature. Practically all the national forests vest in the State and are managed by the State for protective, environmental and productive purposes.

Forest maps

For proper management of forests it is essential to have adequate forest maps. The maps are usually on 4″ to 1 mile or 1 to 15,000 scale or at least 2″ to 1 mile or 1 to 25,000 scale. For the purpose of forest maps, the Survey of India has been carrying out special forest surveys for the various State Forest Departments. In some cases limited surveys have been carried out by some State Forest Departments as well. The information on the surveys carried out by the State Forest Departments is not readily available.

Table 7.1 gives the information of the total forest area surveyed by the Survey of India for different States as per the Report of the Task Force on Forest Resources Survey of the Planning Commission, Government of India (1972). The information as supplied by the Survey of India in 1971 to the President, Forest Research Institute, Dehra Dun is shown in column 5 while column 4 shows the area as per information of the Ministry of Agriculture, Government of India. Figures need reconciliation. Information for States/Union territories not included in the statement is also required. The production of complete forest maps for the entire forest area of the country is an urgent necessity.

Aerial photographs

Aerial photographs have assumed great importance for forest surveys, etc. At present, the Survey of India co-ordinates aerial photography of all types and scales for all indentors in the country. The photography is carried out by the Indian Air Force and/or the Air Survey Company of India. The preparation and supply of prints is carried out by (a) the Director of Map Publication, Survey of India, and (b) the Air Survey Company of India. With the exception of comparatively smaller areas, major portion of the country is covered by aerial photos on 1:50,000 to 1:60,000 scales. Smaller parts of the country only are covered on 1:32,000 to 1:40,000 or 1:15,000 to 1:20,000 scales. For adopting modern methods of forest surveys already

Table 7.1: Total forest area surveyed for maps by States (area '000 ha)

Sr. No.	State	Total forest area	Surveyed forest area as per information of Ministry of Agriculture	Reserved forest area surveyed as per information given by Survey of India
1	2	3	4	5
1.	Andhra Pradesh	6,410	2,628	1,651
2.	Bihar	3,059	474	—
3.	Gujarat	1,868	1,410	335
4.	Himachal Pradesh	2,158	132	—
5.	Karnataka	3,510	2,150	1,441
6.	Kerala	1,059	270	270
7.	Madhya Pradesh	17,169	3,072	3,072
8.	Maharashtra	6,658	2,415	3,491
9.	Orissa	6,746	356	—
10.	Rajasthan	3,760	103	—
11.	Tamil Nadu	2,214	1,669	1,669
12.	Uttar Pradesh	4,872	4,770	1,315
13.	West Bengal	1,183	686	686
14.	Other States	8,546	No information available	
15.	Union Territories	6,061	No information available	
	Total	75,273	17,542	13,935

developed, aerial photographs for all forest areas on an appropriate scale are essential.

Forest working plans

Forest Working Plans are important documents, usually printed, for each division, describing in detail the summary of basic facts on which the proposals are made and prescribing the methods for future management and detailed prescriptions. Among the summary of facts are descriptions of the tract, configuration of the ground, geology, rock and soil, climate, rain-the national forests vest in the State and are managed by the State for protective, environmental and productive purposes.

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9.	Orissa	6,746	356	—
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developed, aerial photographs for all forest areas on an appropriate scale are essential.

Forest working plans

Forest Working Plans are important documents, usually printed, for each division, describing in detail the summary of basic facts on which the proposals are made and prescribing the methods for future management and detailed prescriptions. Among the summary of facts are descriptions of the tract, configuration of the ground, geology, rock and soil, climate, rainfall water supply, forest distribution, legal position, forest boundaries. rights and concessions, composition of forests, injuries to which crops are liable, details about the utilisation of the produce, agricultural customs and requirements of the people, market rates, lines of export, methods and cost of exploitation, and past and current prices of various forest products. The questions of staff and labour are discussed, besides past history and system of management and results, specially works of improvement, past revenue and expenditure and statistics of growth and yield relevant to the area. The details of wildlife of the area and their bearing on overall forest resources are also discussed. The future management and prescriptions start with the basis of proposals, lay down general objects of management, methods of treatment, proposed working circles and their constitution, allotment of areas and the period of the working plan. For each working circle, the general constitution is discussed with special objects of management, felling series, area statements, analysis and valuation of crops, silvicultural system and rotation adopted, regulations of yield, felling cycles, method of executing fellings, methods of bringing in regeneration, mode of meeting requirements of local people, etc. The working plans also include discussions on wildlife, establishment and labour, control and records, financial forecast, etc.

In India, unfortunately, the entire forest areas of the country are still not covered by working plans. As shown in Table 2.7, only 49.7 m ha of the forest area of the country is covered by working plans, according to the information published by the Ministry of Agriculture, Government of India.

Forest Survey of India

In 1965, the Government of India in collaboration with the Food and Agriculture Organisation of the United Nations initiated a project called the Pre-Investment Survey of Forest Resources, and started it in three zones of the country, namely, northern, central and the southern. The work was later continued independently by the Government of India, and has now taken shape in the Forest Survey of India from 1981. This survey has collected very valuable information of the forest resources of the country. The work has been completed over an area of 60 m ha over various catchments. Based on latest inventory techniques, the Pre-Investment Survey/Forest Survey of India have collected valuable information on various characteristics like number of trees per hectare according to diameter classes, species dispersion, total volume per hectare, volume per hectare by utility classes, etc.

Actual growing stocks

This brings us to the question of forest growing stocks. Table 7.2 gives some of the estimates of forest growing stocks by States/Union Territories made during the last 25 years. Column 6 of this table gives the estimates of growing stocks as made in the publication *100 Years of Indian Forestry* (1961). Column 4 gives the figures compiled at the time of Commonwealth Forestry Conference in 1968. Column 5 gives the growing stock figures as reported in the brochure *India's Forests* (1980) issued by the Inspector-General of Forests, Government of India.

Growing stocks in various forest types

Table 7.3 shows the total growing stocks for specified forest areas in various forest divisions/catchments or districts based on the work done by the Pre-Investment Survey of Forest Resources/Forest Survey of India. The information is of an extremely interesting and useful nature. While a forest division like Udaipur in Rajasthan contains a growing stock of 26 metre^3/ha mainly consisting of teak, *Anogeissus* and *Boswellia*, the forests in the Chenab Valley of Jammu and Kashmir contain a growing stock of 272 metre^3/ha spread over an area of 3.7 lakh ha, mainly consisting of fir, spruce, and deodar. The forests in the Ballarshah catchment of the Chandrapara district of Maharashtra spread over an area of 9 lakh ha contain a growing stock of 40 to 79 metre^3/ha or a total growing stock of 62 m metre^3 consisting of some teak and a large number of miscellaneous species. The forests of the East Godavari river catchment in the districts of Visakhapatnam, East Godavari, West Godavari and Khammam in Andhra Pradesh spread over an area of 6.5 lakh ha contain a growing stock of 98.6 meter^3/ha or a total growing stock of 64.1 m metre^3 consisting of *Xylia*, *Terminalia*, *Anogeissus*, *Pterocarpus*, etc. The Phulbani forests of Orissa in the forest division of

Table 7.2: Estimates of forest growing stocks by States and Union Territories (m metre^3)

Sl. No.	States/Union Territories	As per *Forest Centenary Publication*, 1961	As complied at the time of Commonwealth Forestry Conference in 1968	As per brochure *India's Forests* 1980
1.	Andhra Pradesh	NA	164	165
2.	Assam	7	59	100
3.	Bihar	187	229	71
4.	Gujarat	22	29	14
5.	Himachal Pradesh	73	115	81
6.	Jammu & Kashmir	107	425	98
7.	Karnataka	109	226	53
8.	Kerala	60	85	201
9.	Madhya Pradesh	182	410	600
10.	Maharashtra	112	151	73
11.	Manipur	NA	61	72
12.	Nagaland	NA	6	1
13.	Orissa	81	109	109
14.	Punjab	42	140	—
15.	Rajasthan	—	54	3
16.	Tamil Nadu	—	53	4
17.	Tripura	—	15	10
18.	Uttar Pradesh	91	123	96
19.	West Bengal	36	16	16
20.	Andaman & Nicobar Islands	17	21	71
21.	Arunachal Pradesh	NA	117	117
22.	Goa	NA	3	3
	Total	1,126	2,606	1,958

NA: Not available.

Note: Annual Report of Karnataka Forest Department (1980-81) gives the growing stock figure of Karnataka Forests as 223 m metre^3.

Table 7.3: Typical growing stocks in Indian forests

Sl. No.	Division or catchment	Forest area lakh ha	Growing stock metre³/ha	Total growing stock metre³	Bamboo growing stock	Remarks
1	2	3	4	5	6	7
1.	Udaipur forest division (Rajasthan)	4.5	26.0	11.7	—	*Anogeissus*, Teak, *Boswellia*, etc.
2.	Adilabad district (Andhra Pradesh)	6.34	52.8	33.4	—	Teak, Anduk, Salin, etc.
3.	Wadsa catchment (Chandrapara district)	6.7	83.3	55.8	1 m tonne green	Teak, Misc., etc.
4.	Ballarshah catchment (Chandrapara district, Maharashtra)	9.0	79 to 40	62.0	1.4 m tonne green	Teak and misc.
5.	Visakhapatnam, E. Godavari, W. Godavari and Khammam of East Godavari River catchment (Andhra Pradesh)	6.5	98.6	64.1	—	*Xylia*, *Terminalia*, *Anogeissus*, *Pterocarpus*
6.	Chenab Valley (J & K)	3.7	272.0	101.0	—	Conifers

Table 7.3 (*Contd.*)

1	2	3	4	5	6	7
7.	(a) Rajgarh	0.69	68.9	4.8	—	Chil, kail, oaks, etc.
	(b) Nahan (H.P.)	0.75	82.0	6.1	—	Sal
8.	Phulbani (Orissa) (Phulbani, Balliguda, Parlakhimedi)	10.05 (approx)	32.6	32.8	–	Bamboo, sal, salai, misc.
9.	Nowgong, Karbi Anglong districts (Assam)	9.62	148.0	142.0	1.22 AD	
10.	Kameng and Subansiri (Arunachal Pradesh)	3.0	—	17.3		
11.	Tirap and Lohit (Arunachal Pradesh)	2.6	119.0 to 241.0	33.0 (approx.)		
12.	Tripura	1.3 trees 4.4 bamboos	—	12.0 (approx.)		
13.	Meghalaya	—	—	81.0	3.3	Sal and misc.
14.	Manipur	7.6	—	67.0		
15.	South West Bihar	18.02	—	58.0		

Table 7.4: Estimates of gross annual increment (in m metre^3) **by States and Union Territories**

Sl. No.	States	As per *Forest Centenary Publication* 1961	As per *India Forest Statistics* 1960-61 issued in 1961	As compiled at the time of Commonwealth Forestry Conference (1968)
1.	Andhra Pradesh	NA	NA	0.75
2.	Assam	NA	NA	0.74
3.	Bihar	8.24	8.95	8.44
4.	Gujarat	0.51	NA	0.56
5.	Himachal Pradesh	0.42	1.67	0.67
6.	Jammu & Kashmir	0.62	0.82	0.86
7.	Karnataka	0.91	0.41	0.49
8.	Kerala	0.28	0.30	11.00
9.	Madhya Pradesh	NA	4.11	3.44
10.	Maharashtra	NA	2.71	1.46
11.	Nagaland	NA	NA	4.04
12.	Orissa	0.85	0.91	0.88
13.	Punjab	—	—	—
14.	Rajasthan	NA	NA	0.51
15.	Tamil Nadu	NA	0.27	0.25
16.	Tripura	NA	NA	0.17
17.	Uttar Pradesh	2.93	3.24	1.31
18.	West Bengal	1.39	1.42	0.88
19.	A & N Islands	0.21	0.22	0.15
20.	Arunachal Pradesh	NA	NA	0.57
	Total	15.72	25.00	33.27

NA: Not available.

Note: Punjab figures combined with Himachal Pradesh.

Phulbani, Balliguda and Parlakhimedi covering an area of 10.05 lakh ha have an average growing stock of 32.6 metre^3/ha or a total growing stock of 32.8 m metre^3, mainly consisting of sal, salai and other miscellaneous species. The forests of Nowgong and Karbi Anglong districts in Assam spread over an area of

9.6 lakh ha have a growing stock of 148 metre^3/ha or a total growing stock of about 142 million m^3 besides an estimated 1.2 m tonnes (air dry) of growing bamboos. The figures of growing stocks for districts/river catchments in Table 7.3 when analysed with the figures of growing stocks by States given in Table 7.2 show *prima facie* serious anomalies. Assessment of correct and consistent figures of growing stocks and their publication at 5-10 year intervals is a matter of great importance for proper forest management. The FAO publication *Forest Resources of Tropical Asia* (1981) assessed the forest growing stock in India's forests based on the Pre-Investment Survey of Forest Resources of the various regions at about 3,680 m metre^3 above 10 cm diameter breast height in 1980.

Actual increments

Besides forest growing stocks, the question of total annual increments or growth in Indian forests is vital. Table 7.4 gives the gross annual increment or growth in Indian forests by States and Union Territories according to various publications. There are very wide variations and some of the figures are obviously widely off the mark, especially when a comparison is made with respective growing stock figures. Unfortunately, the information on the annual growth in Indian forests is even more incomplete and unsatisfactory than the information on forest growing stocks. Possibly, the increment in Indian forests may be of the order of 50-60 m metre^3 per annum though any figure would be largely a guess work. The computation of increment in different forest areas at least by main species and its correlation with forest management are extremely important and this information is seriously lacking in India today.

CHAPTER 8

Production Forestry

Actual production

Besides affording environmental protection and conservation, an almost equally important function of forests is the production of wood and a host of non-wood products, all of which together have a major bearing on the national economy. The production of industrial and fuel wood from the forests of India has rapidly increased during the last 45 years as is shown in Table 8.1.

Even though the production of industrial wood has steadily increased several fold during the last 30 years, the production continued to be at a dismally low level compared to the potential. The important causes of this are—inadequate investments in forestry on the management and research side, inadequate protection, frequent fires, heavy incidence of grazing in most forests and inadequate efforts at regeneration, natural or artificial.

Uses of wood

Wood is a versatile raw material which is used by man from the cradle to the grave. Among the well-known uses of wood are—for making agricultural implements, in irrigation, timber industry, in bearings, in making bent-wood articles, boot-lasts and shoe heels, in boxes, crates, packing cases for various purposes, in making brushes, brooms, in carts and carriages, in frame-work, axle, wheels, hub, spokes, in making barrels, casks, engraving and printing blocks, in fence posts, fresh water piles, in furniture, cabinet making, mathematical instruments, in mine

Table 8.1: Production of industrial and fuelwood from Indian forests (in m metre^3)

Year	Out-turn of industrial wood	Out-turn of fuelwood
1935-36 to 1938-39 (yearly average)	1.74	6.53
1940-41	1.82	NA
1942-43	2.39	NA
1945-46	2.03	NA
1947-48	1.79	NA
1949-50	2.66	10.42
1950-51	2.50	11.12
1951-52	2.78	10.37
1952-53	3.31	9.41
1953-54	3.04	9.27
1954-55	3.71	10.56
1955-56	4.16	10.81
1956-57	4.40	10.18
1957-58	4.70	10.98
1958-59	4.70	11.96
1959-60	5.54	11.68
1960-61	5.31	11.64
1961-62	5.60	10.75
1962-63	7.60	13.20
1963-64	7.20	12.30
1964-65	6.50	12.60
1965-66	8.61	13.09
1966-67	9.28	12.24
1967-68	9.57	13.11
1968-69	9.37	11.59
1969-70	8.93	12.86
1970-71	9.10	13.70
1971-72	9.40	15.00
1972-73	9.70	15.00
1973-74	NA	NA
1974-75	9.80	16.70
1975-76	9.90	16.60
1976-77	11.10	15.40
1977-78	11.20	16.20
1978-79	12.00	17.30
1979-80	13.50	18.50

work and pit-props, in motor lorry and bus badies, in musical instruments, in pattern making, pencils and pen-holders, in pictures and slate frames, railway carriages and wagons, railway sleepers, road paving blocks, shingles, ship and boat building, sports goods including billiard cues, bows and arrows, cricket bats, cricket stumps and balls, fishing rods, golf-clubs, hockey sticks, badminton and squash rackets, carrom board, in making guns and rifles, tent poles and tent pegs, bobbins, textile accessories, shuttles, picker arms, tobacco pipes, tool handles and axe helves, toys and model making, turnery, carving and combs, in making match boxes and splints, for wood pulp, paper and newsprint, for making veneers, plywood and laminated structures, walking sticks, umbrella handles, battery separators, etc., and as fuel.

Demand for industrial wood

Many studies have been made in the past on timber and fuel trends and prospects. The *Country Report for India* (*1951*) *for the Far East, Timber Trends Survey* estimated the industrial wood requirement for 1960, 1970 and 1975. In 1960 and 1962, Von Monroy and Venkataraman projected the demand of industrial wood for 1960, 1965, 1970 and 1975. In September 1965, the Ministry of Agriculture and Irrigation (Department of Agriculture) drew an Indicative Plan for Forestry in India for the period 1965-85 as part of the Indicative World Plan sponsored by the Food and Agriculture Organisation (FAO) of the United Nations. The Plan showed that the total industrial wood requirement would rise from 14 m metre^3 (round) in 1970 to 22, 32 and 50 m metre^3 (round) in 1975, 1980 and 1985 respectively.

Regarding the availability of industrial wood, the Indian Indicative Plan prepared in 1965 by the Government of India, Ministry of Agriculture, estimated for 1985 as follows:

"Besides the yield of 13.3 m metre^3 another 1.0 m metre^3 may be expected from better logging and 2.0 m metre^3 from improvement fellings in the depleted forests, 3.4 m metre^3 from extra areas to be clear felled to increase the tempo of plantations to be rehabilitated and 12.0 m metre^3 from earlier plantations, i.e. in all 31.7 m metre^3 or say 32 m metre^3 against the requirement of 50 m metre^3." Unfortunately, this estimated quantity of industrial wood by 1985 is not at all likely to materialise.

A detailed study on the subject was also undertaken in 1970 by G.R. Gregory, Ford Foundation Consultant to the Planning Commision when a document titled *Forest Products Production-Trade, Consumption, Quantity and Value of Raw Material Requirement* was issued. This was discussed in detail by the representatives of the Ministry of Agriculture, Planning Commission, Chief Conservators of Forests and others interested in forests and forest industries development at a seminar on "Forest Project Planning for Economic Development" held in December 1971 at the Forest Research Institute and Colleges, Dehra Dun. In this study based on the population growth and per capita gross domestic product, consumption patterns including the impact of imports and exports were worked out. Detailed break-up had been made separately for sawnwood, coniferous and broad-leaved, sleepers for railways, plywood, veneer, particle board and fibreboards. Separate studies were also made for various kinds of pulp and paper products from different raw materials like hardwoods, conifers, bamboos and other fibrous materials. The requirement of pit props, poles and fuelwood was separately prepared and identified.

During the years 1972-74, the National Commission on Agriculture critically reviewed the material requirements of industial wood and fuelwood which is since incorporated in the National Commission on Agriculture Report, 1976. The Commission assumed that the income elasticities of demand of sawnwood would decrease from 0.8 to 0.6 and that for round wood from 0.5 to 0.25. The Commission made two estimates of demand of industrial wood, high and low corresponding to the two estimates of GDP. The conclusions of the Commission are given in Table 8.2 for aggregate raw material requirements for 1980, 1985 and 2000 A.D. under assumptions of high and low income growths.

The NCA analysis shows that by 1985, the requirement of industrial wood would rise to 35 or 30 m metre^3 on assumptions of high or low income growths respectively, while the corresponding figures for the year 2000 would be 64 and 47 m metre^3.

Table 8.2: Aggregate wood requirement for 1980, 1985 and 2000 [in '000 metre^3 (round)]

Item	Wood requirement					
	High Income Growth			Low Income Growth		
	1980	1985	2000	1980	1985	2000
Sawnwood	14,100	18,300	29,650	13,145	15,665	22,940
Panel products—						
plywood & venner	600	965	2,155	520	700	1,345
Fibreboard	95	125	200	85	105	155
Pulp and paper	4,175	6,055	17,695	3,675	4,715	9,680
Matchwood	535	680	1,415	535	680	1,415
Roundwood	7,390	9,055	13,335	7,045	8,165	11,645
Total	26,895	35,180	64,450	25,005	30,030	47,180

Consumption of timber in different states

A Transport Group of the Planning Commission, Government of India, in 1967 undertook a study on inter-State movement of timber production, extent of imports into and exports from and apparent consumption of timber in various States in 1965-66. These figures are given in Table 8.3.

The overall figures are not consistent, but are indicative of the likely trends.

Prices of industrial wood

The various projections of demand of industrial wood are almost unanimous in showing the comparatively high requirements of industrial wood, while the actual production has lagged behind. This has inevitably resulted in abnormally high prices of industrial wood. The State Forest Departments supply railway sleepers to the Government railways on a mutually agreed basis. The prices at which these sleepers are supplied are fixed somewhat lower than the market prices of wood. Table 8.4 shows the prices paid by the Indian Railways to the State Forest Departments for broad gauge track sleepers over the last 42 years for different species of timber.

Table 8.3: Annual off-take, pattern of movement and apparent consumption of industrial wood during 1965-66 in India by States ('000 tonnes)

Sl. No.	States/Union Territories	Annual off-take of industrial wood	Movement out of the State/U.T.	Movement into the State/U.T.	Apparent consumption
1.	Andhra Pradesh	157	54	151	255
2.	Assam	203	121	41	123
3.	Bihar	355	247	125	234
4.	Gujarat	122	76	227	272
5.	Haryana	14	147	383	251
6.	Himachal Pradesh	249	208	2	44
7.	J & K	276	137	22	161
8.	Karnataka	346	276	19	89
9.	Kerala	200	215	78	64
10.	Madhya Pradesh	944	582	42	405
11.	Maharashtra	258	108	481	630
12.	Manipur	6	3	—	3
13.	Nagaland	13	—	—	13
14.	Orissa	375	280	14	110
15.	Punjab	40	241	376	174
16.	Rajasthan	44	11	72	105
17.	Tamil Nadu	25	23	197	200
18.	Tripura	23	17	—	6
19.	Uttar Pradesh	679	401	240	518
20.	West Bengal	162	23	519	658
21.	Andaman & Nicobar Islands	72	20	—	52
22.	Arunachal Pradesh	79	19	—	60
23.	Dadra & Nagar Haveli	2	—	—	2
24.	Delhi	—	—	217	217
25.	Goa, Daman & Diu	10	—	Neg.	10
	Total	4,654	3,209	3,206	4,656

***Including Meghalaya and Mizoram**

Based on Commodity Transport Studies, Timber & Timber Products, 1967.

Table 8.4: Prices paid for B.G. track sleepers by the Railways to the State Forest Departments

Year/Species	Sal	Deodar	Kail	Fir	Chir
	Rs. As. P	Rs. As. P	Rs. As. P	Rs. As. P	Rs. As. P
1938-39	4-12-8	4-12-5	3-8-0	2-13-3	3-12-10
1946-47	9-11-6	NA	NA	NA	NA
1951-52	17-12-0	NA	NA	NA	NA
1956-57	19-00	19-00	NA	NA	NA
1960-61	21-84	31-80	19-95	17-59	16-16
1964-65	34-50	NA	25-20	23-70	NA
1969-70	38-82	42-00	NA	NA	NA
1981-82	188-00	187-00	NA	112-00	NA

NA—Not available.

The wholesale prices during the years 1950-51 to 1980-81, the average rate of inflation and the purchasing power of the rupee are depicted in Table 8.5 below.

Table 8.5: Wholesale prices (at 1970-71 = 100)

	1950-51	1960-61	1970-71	1980-81
Indices	47.5	55.1	100.0	257.3
Average rate of inflation (%)		1.78	6.24	10.25
Purchasing power in Rs.	1.0	0.82	0.45	0.19

It would be seen that while the wholesale price index rose about 5.2 times from 1950-51 to 1980-81, the prices of sal broad-gauge sleepers increased 11 times during the years 1951-52 and 1981-82. The price of fir sleeper, which was Rs. 2, 13 annas in 1938-39 rose to Rs. 112 in 1981-82.

Potential productivity

While the actual production from Indian forests continues to be very low at present, the potential productivity is very high.

In this connection reference may be made to the work of S.S. Paterson who has estimated the potential productivity of world's forests in terms of climatic factors. Paterson has proposed a CVP index (climate, vegetation and productivity index) with a formula by which the potential productivity of a given site can be calculated. This CVP index modified to suit local conditions has proved useful in giving broad estimates of regional forest productivity in various countries. Seth *et al.*, 1971 in their study on potential productivity of Indian forests have calculated this productivity for different States as per Paterson's CVP index.

The rising demands for forest raw materials due to rapidly increasing population and the increasing pressure on land for agriculture and other urban uses, coupled with the low production from our forests has caused India to be classified on the world map of forest resources as belonging to a deficit zone. As industrialisation has progressed and the industries are striving for expansion, the demands for forest raw materials have sprung up suddenly to find the foresters and the forests alike ill-prepared to fulfil them.

It has, therefore, become essential, besides increasing the area under forests, to maximise wood production from the available forest area in the country to meet the increasing national demand of wood and non-wood products.

The broadest regional classification of forests has essentially a climatic basis. The community of vegetation which finally attains reasonable stability on a particular site can be assumed to be adopted to maximum sustained long-term utilisation of the environmental resources in biological productivity. As the environment is chiefly conditioned by the operations of climatic factors, the soil being also in equilibrium with them, a close correlation between the sum total of these factors and the biological productivity of a site may be expected. The various factors of climate reflect not only the degree to which conditions are favourable for optimum biological activity but also the intensity of factors which retard or limit such activity. If, therefore, the other factors of site are in a state of mutual balance and equilibrium, the productivity potential of a site should be capable of expression through the integrated effect of the climatic factors.

Paterson's formula

Paterson has shown that the mean annual increments of suitably managed indigenous high forests are strongly correlated with climatic indices which denote the combined effect of temperature amplitude, length of growing season, precipitation and solar radiation.

As temperature, precipitation and light are the most important factors for life processes of plants, the Paterson's CVP index proposed is based on these factors with the formula,

$$I=\frac{\mathrm{Tv}\times P\times G\times E}{\mathrm{Ta}\times 12\times 100}$$

where I is the CVP index, Tv is the mean temperature of the warmest month (in °C), Ta is the mean annual range of temperature between the coldest and the warmest months, P is the mean annual precipitation (mm), G is the length of the growing season in months, and E is the evapotranspiration reducer, a factor based on latitude and giving the generalised total annual radiation received as per cent of that at the equator.

Correlation between the CVP index and the maximum or ideal productivity for different regions of the world worked out by Paterson turns out to be significant at 95 per cent probability, the variance of the CVP index contributing to about 80 per cent of the total variance for the ideal site class.

The equation for calculation of productivity, according to Seth *et al.*, 1971, thus comes to $Y=5.2 \log x-7.25$, where Y is the productivity in metre^3/ha and x is the CVP index. CVP index was calculated for over 350 stations in the country for which meteorological data was available, and climato-isophytes (lines connecting places with same CVP index) drawn on a forest map of India resulting in different productivity zones. For each zone, potential productivity was calculated for each State. Table 8.6 gives the average annual production (1977-78) and the potential productivity of wood for different States as calculated by Seth *et al.*, 1971 and is most interesting. For the forests of India as a whole, while the average annual production during the years 1961-65 was only 19.6 m metre^3 and that for the year 1979-80 was 32 m metre^3, the potential productivity is 492 m metre^3. The formula is somewhat defective in so far as it does not take into account the soil factor. Attempts to include this

Table 8.6: Actual annual production and potential productivity of forest areas in different States

State/Union Territory	Forest area (m ha)	Wood production 1977-78 (m metre^3)	Potential productivity (m metre^3/year)
Andhra Pradesh	6.651	1.70	45.04
Assam (including Meghalaya)	4.565	2.08	43.74
Bihar	3.085	0.83	20.47
Gujarat	1.940	0.39	10.94
Jammu & Kashmir	2.081	0.56	10.23
H.P., Punjab and Haryana	2.489	1.07	16.94
Kerala	1.041	0.78	12.74
Madhya Pradesh	17.299	4.57	108.51
Maharashtra	6.686	1.64	43.71
Karnataka	3.520	2.98	32.23
Nagaland	0.310	0.04	2.80
Orissa	6.816	5.20	50.40
Rajasthan	3.764	0.24	16.36
Tamil Nadu	2.218	0.27	20.95
Uttar Pradesh	4.571	3.28	27.62
West Bengal	1.183	0.79	9.83
Andaman & Nicobar Islands	0.635	0.19	6.74
Delhi	0.005	Neg.	0.02
Goa, Daman & Diu	0.103	0.01	1.09
Manipur	0.602	0.11	5.50
Arunachal Pradesh	5.154	0.20	(n.a)
Tripura	0.633	0.16	6.21
Total	75.351	27.32	492.07

factor have not so far succeeded, and further effort in this direction is required. However, it is established beyond doubt that the potential productivity of forests of various States is very much higher than the actual production. Table 8.7 gives the mean annual increment and potential productivity of forest sample plots for some species.

Table 8.7: Mean annual increment (M.A.I.) and potential productivity of some sample plots

Sample plot No. and location	Species	Maximum M.A.I. (metre^3/ha)	Potential productivity (metre^3/ha/year)
10, Dehra Dun Division, Uttar Pradesh	*Shorea robusta*	7.84	8.17
18, South Rajpur Division, Madhya Pradesh	*Shorea robusta*	9.24	6.54
2, Udaipur Division Rajasthan	*Acacia arabica*	4.54	4.55
73, West Almora Division, Uttar Pradesh	*Cedrus deodara*	6.16	7.54
3, Kurseong Division, West Bengal	*Shorea robusta*	9.52	10.37
13, Kurseong Division, West Bengal	*Shorea robusta* (*Plantation*)	9.36	10.27
16, Puri Division, Orissa	*Shorea robusta*	8.33	9.14
8, Lakhimpur Division, Assam	*Artocarpus chaplasha* (*Plantation*)	12.24	10.68
1, South Chanda Division, Maharashtra	*Tectona grandis*	4.20	6.50

It would be seen that the application of Paterson's approach for getting the estimates of productivity of forest lands through the combined effect of climatic factors could be usefully employed under Indian conditions to give broad estimates on a regional basis of the potential productivity of our forests. This is of special importance, as it helps us to know—(i) as to whether the potential production in a given region is being harvested or not, and if not, suitable measures could be taken to step up production to harvest the potential, and (ii) the regions with high productivity indices so that plantation programmes could be concentrated in such areas to get maximum production, as plantations have a better chance of withstanding the economic test if they are raised on sites with high productivity indices.

Change over to intensive forestry

As the NCA report has pointed out, the basic problem therefore is that forestry must come out of the rut of low-investment low-yield practices, in the face of mounting demands for forest products and in view of the need for achieving self-sufficiency and for creating more employment opportunities in the rural areas. A new commercial approach for forestry development has thus to be built up, needless to say, consistent with environmental conservation. Development in the forestry sector continues to be hindered seriously due to paucity of funds and the system under which the development programmes are being financed. The objects defined for production forestry by the NCA interim report on *Production Forestry—Man-made Forests* in August 1972, and reiterated by them in their final report in 1976 are as follows:

1) To raise the per hectare production both in respect of volume and value.

2) To create much more employment for skilled as well as unskilled hands.

3) To give a substantial support to the economy of the backward areas and the tribal population which depends for growth on forestry activities.

4) To expand or establish a large number of industries based on raw material from the forests.

5) To enter the export market in wood and wood products.

6) To have a sustaining impact on the employment in the secondary and tertiary sectors.

Experience of other countries shows that forestry can give higher per hectare return provided it is possible to adopt intensive management including creation of man-made forests on a far larger scale than has hitherto been possible in India, for lack of adequate investment. Limitation of useable land, coupled with ever increasing demand for forest based products, makes it imperative that maximisation of return per hectare of forest lands be attempted. It is necessary to go in for balanced inputs at high cost as against traditional practices with low-cost inputs.

Planning increased production

As the NCA report emphasises, production forestry is a business, and it must therefore be closely linked with marketing and utilisation. A forest production programme in isolation cannot succeed. An adequate capacity in the forest based industries should be planned in such a way that the utilisation of the produce from man-made forestry programmes is synchronised with a specific industry which is to go on steam in future. From the economic standpoint also, there is a strong justification for bringing about a close link between the resource development and utilisation. The profitability of any plantation project when it is considered in isolation is quite different from what it is when linked with utilisation. This is so because in the latter case the profitability is an integrated one.

The most important desirable characteristics of forests for economic wood production in future would be the following:

a) Suitability of the wood produced for the end purposes proposed.

b) Large volumes per unit area.

c) Homogeneity of materials.

d) Accessibility in relation to markets.

By correct choice of species much higher growth rates can be achieved than in natural forests. Consequently, for a given yield, man-made forests need considerably smaller areas than natural forests. However, man-made forests have their problems, viz. selection of species, with reference to site, quality of seeds, difficulties in seed procurement, risks of diseases and insect attack, improvement of techniques, long term effect on soil and productivity, etc.

A change over to intensive man-made forestry will, however, bestow the following advantages:

1) Immediate and long-term increase in timber and pulpwood and availability for meeting demands on an increasing scale.

2) Creating incentive for increasing installed capacity of

industries consuming forest produce, thereby providing additional employment in secondary and tertiary sectors.

3) Planning future production of pulpwood according to market preferences, both internal and international, and reduction of wasteful growth.

4) Built-in soil conservation and environmental programmes.

5) Large-scale additional labour employment opportunities in both skilled and unskilled categories in the primary sector.

6) Increased and planned recreational facilities.

Finally, there must be an incentive for change-over from the low-cost, low-yield forestry to a commercial high-investment, economic and environmental forestry, and for this purpose there should be a rational pricing policy for forest products, specially bamboo and pulpwood which are among the important raw materials required for pulp and paper-making.

Environmental conservation

It is worth pointing out that the concept of intensive commercial forestry envisaged above, generally clashes in no way with the concept of environmental conservation. Forest working plans and working practices do and must ensure site protection and improvement and needs of environmental conservation. No fellings are allowed on broken grounds, along nallah edges or steep slopes or where regeneration is difficult to get. As a matter of fact, intensive plantation programmes should considerably affect and improve the environment. The basic question is of improving the production, consistent with environmental needs. The need and importance of exotic species in this connection deserve to be clarified. It is to be noted that Indian forestry has hitherto worked for barely acceptable results. There has been little or no attempt towards optimisation. Unless the inputs are increased, with sufficient built-in margin to take care of such contingencies as abnormal climatic conditions, out-break of insects and other pests, etc., it may not be possible to get the most out of the land devoted to industrial crops. Here the parallel has to be drawn with agriculture or plantation crops like rubber and coffee. Fertilisation, irrigation, use of pesticides, bacterial and mycorrhizal inoculation, combined with the use of superior genetic strains, are the ways of achieving better results. This, however, involves substantially greater investment than at present allocated to forestry. In this context, it may be remembered that the broad discipline of forestry need not be confined to natural or artificial stands of forest species alone, but should include all land uses like plantation crops such as rubber, palm-oil, cocoanut, cashewnut, etc., in which tree crops are used to harness the productive capacity of the soil. Implementation of this approach requires a drastic re-thinking and re-orientation in the policy of investment in the forestry sector on the productive side. Examples can be multiplied but it may suffice to say that quite apart from working out the economics of optimal utilisation, even essential measures like fire protection, which cost only a fraction of the initial outlay towards raising the plantations, but which are vital for their survival and ultimate use, are often neglected due to lack of funds from the fact that the allocations are not periodically revised in keeping with the needs. Such a feed-back mechanism is essential in order to ensure that the best use is made of the resources at our disposal.

Some intensive development areas have also been identified, which are given in Table 8.8. The table gives the potential productivity index of Paterson as also the potential production metre^3/ha (a) for indigenous or natural, and (b) for exotic species.

Table 8.8: Intensive development areas

State	Potential productivity index (Paterson)	Potential Production metre^3/ha/annum Natural	Exotics
Assam	1,000-1,500	8.35-9.27	17
Uttar Pradesh (Terai Bhabar)	600-1,000	7.20-8.35	15
Madhya Pradesh (Bastar)	500-600	6.78-7.20	14
Karnataka	800-1,200	7.84-8.77	15
Kerala	2,000-5,000	10.76-11.98	23

Regeneration examples

Basically the problem is of increased production whether by natural or artificial regeneration. However, artificial regeneration or man-made forests are much simpler to work in actual practice. The low productivity of forest could be typically illustrated by the West Dehra Dun Forest Division, Uttar Pradesh. Forest education in India celebrated its centenary in December, 1981, presided over by the then Prime Minister of India at Dehra Dun. Rightly indeed, the Dehra Dun forests which have been scientifically managed for 120 years could be the model for forest management. Despite this the working plan for West Dehra Dun Division by K.N. Singh for the period 1979-80 to 1988-89 for an area of about 48,000 ha with excellent soils and high rainfall prescribes an yield of less than 0.2 $metre^3$/ha. The reasons for this are obvious; regeneration has failed to come up in many places, Lantana covers extensive areas and efforts at research continue to be utterly incommensurate with the requirements and the problems.

Man-made forests

Adopting the definition accepted at the World Symposium on Man-made Forests held in Australia in 1967, such forests may be defined as the forest crops raised artificially either by sowing or planting. Such forests would thus include afforestation, i.e. forests established artificially by afforestation on land which previously did not carry forests, re-afforestation, i.e. forests established artificially by re-afforestation on land which carried forests earlier, and artificial regeneration. Man-made forests would thus include plantations raised for increasing the productivity of forests or other objectives, and also soil conservation, afforestation as well as farm and extension forestry.

Although management strides had been taken in forestry in pre-independence India, the total area of man-made forests in India in 1948 was not more than 2 lakh ha.

Champion and Seth (1968) estimated the area (Table 8.9) planted in various States up to 1956.

The publication *Forestry in India* (1967) issued by the Ministry of Agriculture estimated that the extent of area planted under important species in the country up to the end of 1965 was 9.34 lakh ha (Table 8.10).

According to a paper presented in 1972 at the Symposium on Man-made Forests in India at Dehra Dun by the author of this

Table 8.9: Area planted in various States

State	Total area (ha) planted up to 1956
Andhra Pradesh	18,400
Assam	—
Bihar	8,500
Maharashtra	—
Gujarat	—
Karnataka (Mysore)	46,500
Kerala	1,08,800
Madhya Pradesh	10,300
Tamil Nadu (Madras)	66,800
Orissa	4,300
Punjab	14,100
Rajasthan	13,400
Uttar Pradesh	78,500
West Bengal	15,500
Total	3,85,100

Table 8.10: Area planted under important species in India up to 1965

('000 ha)

Teak	191
Other broad-leaved species	643
Eucalyptus species	80
Conifers	21
Total	934

book, the man-made forests in India created up to 1968-69 extended over 1.5 m ha; their distribution by main species and regions is given in Table 8.11. The details of man-made forests up to 1968-69 by States and by principal species in the different regions are given as Annexures 1—4.

Table 8.11: Extent of man-made forests in India created up to 1968-69 by main regions and species ('000 ha)

Sl. No.	Species	Name of Region				
		North Eastern	Western & Central	Southern and South Eastern	Northern	Total
1.	Teak	22.6	65.9	179.9	17.1	285.5
2.	Sal	9.0	—	—	20.0	20.0
3.	Sissoo	—	—	—	47.2	47.2
4.	Conifers	2.8	—	—	24.0	26.8
5.	Softwoods	4.0	—	37.2	81.7	72.9
6.	Eucalyptus spp.	12.2	85.2	118.9	67.7	284.0
7.	Wattles	—	—	22.4	—	22.4
8.	Bamboos	—	9.3	13.4	47.2	69.9
9.	Casuarina	—	4.0	25.3	—	29.3
10.	Other fuelwoods	—	—	77.8	—	77.8
11.	Babul	—	—	—	37.0	37.0
12.	Khair	—	5.2	—	30.8	36.0
13.	Sandal	—	—	1.8	—	1.8
14.	Cashewnut	—	6.8	67.0	—	73.8
15.	Rubber	—	—	5.1	—	5.1
16.	Miscellaneous	125.4	63.4	104.0	155.1	465.8
	Total	167.0	230.8	652.8	477.8	1,537.4

Forest plantation programmes

Up to 1979-80, man-made forests were created in India over an area of about 3.68 m ha. The target of creation of such forests during the Sixth Five Year Plan is 2.32 m ha (Table 8.12).

During the year 1981-84, the number of plants planted annually in India increased from about 132 crores to 232 crores, while the target for 1984-85 planting is 250 crores. Yearwise and State-wise details are given in Table 8.13.

Table 8.12: Target of creation of man-made forest (lakh ha)

	Up to end of 1979-80	During Sixth Plan	Total
Social Forestry Programme	14.8	15.2	30.0
Industrial Plantations	22.0	8.0	30.0
Total	36.8	23.2	60.0

Non-wood products

Apart from wood, forests are important for a large number of other products, e.g., bamboos, tendu leaves, oilseeds, tans and dyes, *kutch* and katha, gums, pine resin, lac and honey, drugs, spices, insecticides, edible products, *mahua* flowers, tamarind, cashew, clove, etc., fibres and flosses and distillation products of wood, etc. These are dealt with below.

BAMBOOS

Bamboo is called the poor man's timber. India has rich bamboo resources. With about 20 genera and 113 species spread over an area of about 10 m ha, perhaps the world's largest resources of bamboos exist in this country. Areas particularly rich in bamboos are the north-eastern region, Central India, Western Ghats and the Andamans. The State-wise area and annual potential yield of bamboos according to the Central Forestry Commission is given in Table 8.14.

It is estimated that the present annual production of bamboo is about 3.2 m tonnes. Of all the different species only about 10 species are being commercially exploited. These are *Bambusa arundinacea*, *B. nutans*, *B. tilda*, *Dendrocalamus hamiltonii*, *D. strictus*, *Melocauna baccifera*, *Ochlandra ebracteata*, *O. scriptoria* and *O. travancorica*. A few other species are used on a very limited scale, mostly in cottage industries of one kind or another. Management of bamboos is based on the physiologic development of clumps. The yield of bamboos varies considerably depending upon the intensity of stock and biotic conditions. The new clumps are produced from the rhizome along the periphery of the clumps. In the moist and dry areas of Madhya

Table 8.13: Yearwise achievements/targets under afforestation from 1981-82 to 1984-85

(Seedlings planted/to be planted in lakh number)

S. No.	State/UT	Achievements			Targets 1984-85
		1981-82	1982-83	1983-84	
	States				
1.	Andhra Pradesh	680.00	1,243.00	1,576.71	1,800.00
2.	Assam	313.00	306.00	349.00	400.00
3.	Bihar	553.60	901.00	1,069.58	1,200.00
4.	Gujarat	1,494.00	2,468.00	2,883.97	3,000.00
5.	Haryana	600.00	760.00	906.17	1,000.00
6.	Himachal Pradesh	277.00	468.00	506.54	500.00
7.	Jammu & Kashmir	80.00	205.00	108.86	250.00
8.	Karnataka	1,414.00	1,768.00	1,950.00	2,500.00
9.	Kerala	162.00	619.00	649.97	600.00
10.	Madhya Pradesh	2,456.00	2,839.00	2,718.00	3,200.00
11.	Maharashtra	874.00	2,276.00	1,959.00	1,550.00
12.	Manipur	63.29	69.00	86.42	100.00
13.	Meghalaya	35.42	82.00	63.11	100.00
14.	Nagaland	66.12	95.00	91.80	120.00
15.	Orissa	607.41	1,038.00	1,068.51	1,050.00
16.	Punjab	373.00	547.00	600.01	700.00
17.	Rajasthan	305.00	368.00	580.70	550.00
18.	Sikkim	36.00	50.00	68.00	80.00
19.	Tamil Nadu	817.00	1,024.00	1,075.11	1,050.00
20.	Tripura	147.60	127.00	149.00	100.00
21.	Uttar Pradesh	1,052.00	2,305.30	3,400.00	3,300.00
22.	West Bengal	430,00	677.00	734.00	1,150.00
	Union Territories				
23.	A & N Islands	80.40	84.00	84.38	100.00
24.	Arunachal Pradesh	58.00	18.00	53.87	150.00
25.	Chandigarh	—	4.00	4.50	5.00
26.	D & N Haveli	9.51	27.00	27.00	25.00
27.	Delhi	—	31.00	28.38	25.00
28.	Goa, Daman & Diu	—	26.00	23.85	30.00
29.	Mizoram	204.00	257.00	300.00	350.00
30.	Pondicherry	—	13.00	2.67	10.00
31.	Lakshadweep	—	—	0.43	5.00
	Total	13,188.35	20,785.00	23,119.54	25,000.00

Table 8.14: State-wise bamboo bearing areas and potential annual cut

Name of State	Bamboo area sq km	Potential availability (lakh tonnes)
Andhra Pradesh	19,790	2.55
Arunachal Pradesh	7,779	2.00
Assam	10,000	12.10
Bihar	5,294	2.00
Gujarat	1,936	0.46
Himachal Pradesh	104	0.03
Jammu & Kashmir	Negligible	—
Karnataka	6,000	4.75
Kerala	631	1.08
Madhya Pradesh	14,864	8.00
Maharashtra	8,500	3.00
Manipur	2,500	2.00
Orissa	10,500	4.89
Punjab & Haryana	Not available	0.09
Tamil Nadu	5,388	Not available
Tripura	2,849	2.15
Uttar Pradesh	4,000	0.41
West Bengal	164	0.08
Total	1,00,281	45.09

Pradesh, annual yield in typical areas was calculated at 1.2 and 0.6 tonnes/ha annum, while in North Kanara Division such yield was calculated at 0.6 tonnes/ha/annum.

Kurz listed 124 uses for bamboos in India and the list has been updated by subsequent workers, but the amazing bamboo continues to find new uses. The strength of bamboo culms, their straightness, lightness combined with hardness, range in size, abundance, easy propagation and the short period in which they attain maturity make them suitable for a variety of purposes, including houses, mats, scaffoldings, ladders, bridges, fences, sticks, tool handles, brushes, pipes, fans, umbrellas, toys, sports goods, musical instruments, spears, bows and arrows, boats, rafts, fishing rods, caps, baskets, flowerpots, furniture, chicks, kites and in paper manufacture. As a living plant it is used for hedges and in landscape gardening. It is valuable as a windbreak and is particularly useful for preventing soil erosion on account of its interwoven root system.

Bamboo leaves are used for thatching and are also valued as fodder; elephants in particular are fond of them. Dried and mature bamboo leaves are used for deodorising fish oils. Bamboo sheaths are used in linings of hats and sandals, they are also used in an artistic way for dried-flower arrangements. Bamboo seeds are extensively eaten by the poor during famines.

The young and tender shoots of certain bamboos are made into pickles and vegetables that are considered to be delicacies. In medicine too, bamboos have enjoyed a considerable reputation. *Tabashir* or *banslochan*, which is precipitated in the form of amorphous silica in a microscopically film state within the internodes of many bamboos, is used as a cooling tonic and aphrodisiac. Its presence is generally detected by a rattling sound when the bamboo culms are shaken. Because of the extraordinary range of uses to which bamboos are put, they have assumed worldwide importance.

Bamboo is vital in India today for the production of paper. About 1.8 m tonnes of bamboos are being utilised annually at present for the manufacture of paper. There is a large unexploited potential of bamboo in the States of Arunachal Pradesh, Assam, Meghalaya, Mizoram, Manipur, Tripura and the Bastar district of Madhya Pradesh.

Gregarious flowering

Gregarious flowering is a peculiar phenomenon, specific to bamboos. It occurs at long intervals with a range of 25 to 40 years in the case of *Dendrocalamus strictus* and the flowered clumps die after seeding. From the seeds produced, a new generation starts, in place of the vanished crop. The process of gregarious flowering spreads over a number of years (4 to 8 years normally). As a result of gregarious flowering, young seedlings of bamboo appear in millions and cover the floor of the forest as a carpet. They require strict protection from fires and grazing to develop further, and ordinarily take 8 to 12 years to form new clumps of exploitable sizes. This period of clump formation may be appreciably reduced, if attempts are made to minimise the intensity of competition amongst the young seedlings.

Frequent fires and heavy grazing have deleterious effect on bamboo growth, and lack of after-care of flowered areas has resulted in shrinking of bamboo areas. There are considerable areas where bamboo forests have grossly degraded and presently are almost unproductive. The clumps in such areas are either congested or a mass of large stumps. One of the solution for the improvement of such degraded clumps is to clearfell them, and, thereafter, provide rigid protection against fires and grazing.

For increasing bamboo resource, bamboo plantations have been taken up on a large scale. Unfortunately, plantations have not always been successful. Bamboo trade has been successfully nationalised in Madhya Pradesh producing a quantity of 3.6 lakh tonnes of commercial and industrial bamboo in 1977-78, and giving a gross revenue of Rs. 9.2 crores, the net revenue being Rs. 5.9 crores in that year.

Growing stock of bamboos

The growing stock of bamboo in the area surveyed by the Forest Survey of India/Pre-Investment Survey, as quoted by Tewari (1980) are given in Table 8.15.

TENDU LEAVES

Tendu (*Diospyros melanoxylon*) leaves are of great commercial importance in India and are used as wrappers of tobacco to produce *bidi*. It is a medium sized tree found throughout the dry forests of the plains, chiefly in Madhya Pradesh and Orissa and to a lesser extent in Andhra Pradesh, Bihar, West Bengal, Maharashtra, Tamil Nadu, Gujarat, Rajasthan and southern Uttar Pradesh. In certain parts of the country, the leaves of *apta* or *ashitri* (*Bauhinia racemosa*) are also used as wrappers in the manufacture of *bidi*.

The annual collection of *tendu* leaves in the country is esti-

Table 8.15: Growing stock of bamboo surveyed by Forest Survey of India/Pre-Investment Survey

Name of State (catchment)	Forest area surveyed ('000 ha)	Growing stock of bamboo ('000 metric tonnes)
Arunachal Pradesh	126	1,040
Assam (hills)	749	613
Assam (plains)	1,477	1,398
Manipur	1,174	11,433
Mizoram	1,278	2,960
Tripura	578	773
Meghalaya	1,927	203
Maharashtra (Wadsa)	681	2,151
Maharashtra (Sondad)	326	221
Maharashtra (Ballarshah)	903	1,439
Madhya Pradesh (Bastar)	3,119	1,300
Orissa	6.746	4,680
Andhra Pradesh (East Godavari)	655	1,500
Andhra Pradesh (Mehbubnagar)	194	98
Kerala (Central and South)	506	1,195
Total	20,439	31,004

Note: The above figures are in some places at variance with the figures in Table 8.15 and need reconciliation.

mated at 3.5 lakh tonnes, of which about 45 per cent come from Madhya Pradesh. The annual collection in Orissa and Maharashtra is estimated at 50,000 tonnes each, and in Andhra Pradesh at around 40,000 tonnes. The remaining production is shared by Bihar, Gujarat, Rajasthan, Uttar Pradesh and West Bengal. Coppice shoots and root suckers of the tree produce good quality leaves and for this purpose; pollarding and pruning are practised in certain parts of the country. Pollarding/pruning is usually undertaken during the months of February/

March, while plucking starts about the middle of April and continues up to the end of May, extending sometimes up to the first/second week of June. With the onset of rains, collection of leaves stops because of difficulty in drying. Utilisation of *tendu* leaves is spread all over the country throughout the year.

The Government of India has prescribed grade standards for *tendu* leaves and notified the *Tendu* (*Bidi* Wrapper) Leaf Grading and Marking Rules, 1963, under the provisions of the Agricultural Produce (Grading and Marking) Act, 1937. The Government of India also took recourse to the Indian Customs Act, 1962 and prohibited with effect from 1965, export of *tendu* leaves unless the same were graded and marked in accordance with the prescribed standards.

Madhya Pradesh has successfully nationalised the collection of *tendu* leaves and earned steadily increasing revenue, reaching gross revenue of Rs. 33 crores in 1978-79, the net revenue being Rs. 21.9 crores. The collection provides large-scale employment to the local people. Labour earns good wages in the collection of *tendu* leaves. The wage rate more than doubled in the last decade (in 1970 Rs. 15 per bag of 50,000 leaves which rose to Rs. 30 in 1979). During the year 1978 it was estimated that Rs. 9.28 crores were distributed as wages to the labourers in Madhya Pradesh on this work. It is estimated that on an average each family collecting *tendu* leaves earned about Rs. 1,500 yearly in 1979.

OILSEEDS

The total requirement of vegetable oil in India at present is estimated to be 4 m tonnes annually against which only 3 m tonnes are indigenously available. To meet the shortage during 1977-78, 9 lakh tonnes of edible oils and tallow fat were imported at a cost of about Rs. 1,000 crores. Although concerted efforts at producing more edible oils are being made, the results so far are inadequate. The forest oilseeds can make a sizeable contribution in meeting the vegetable oil demands of the country.

The important oilseeds of forest origin are—*mahua* (*Madhuca latifola*), sal (*Shorea robusta*), *karanj* (*Pongamia pinnata*), *neem* (*Azadirachta indica*), *kusum* (*Schleichera oleosa*), *dhupa* (*Vateria indica*), *nahor* or *nagkeshar* (*Mesua ferrea*), *undi* (*Calophyllum* *inophyllum*), *pisa* (*Actinodaphne hookeri*), *palu* (*Salvadora oleoides*) and *kokam* (*Garcinia indica*). These trees occur both in the forests and on village lands, roadsides, etc.

Sal is a very important forest tree, occurring gregariously over extensive areas in Uttar Pradesh, West Bengal, Assam, Orissa, Madhya Pradesh and in small areas in Andhra Pradesh. The sal seed (kernel) has an oil content of nearly 12.5 per cent. The oil extracted from the sal seed is now acceptable in the soap industry and its de-oiled meal is used as a cattle or poultry feed. Sal oil is a substitute for cocoa butter in making chocolates which is used for export for this purpose, and has thus assumed great importance.

Oils produced from most of the seeds referred to above are used in various industries particularly soap industry. Some of these like *mahua* and *neem* oils are already established industrial raw materials; others like *karanj* and *kusum* have come into large scale use in recent years, while efforts to exploit sal seeds as a source of vegetable oil have started bearing fruit only since 1968.

The Directorate of Oilseeds Development, Ministry of Agriculture and Rural Development, Government of India, has prepared an estimate of production and potential of nine important oilseeds of tree origin based on the surveys and investigation conducted by the erstwhile Indian Central Oilseeds Committee, Directorate of Oilseeds Development, Khadi and Village Industries Commission and Messrs Hindustan Lever Ltd. The total potential and the estimated availability (1970-71) are given in Table 8.16.

The main bottlenecks in increasing the collection of minor oilseeds of tree and shrub origin and their utilisation in soap making and other industrial uses are as follows:

1) Low price paid to seed collectors,
2) Inadequate organisation for collection.
3) Inadequate road communications.
4) Lack of storage facilities.
5) Short periods of collection.
6) Large amounts of finance required during the short collection period.
7) High cost of processing.
8) Scattered distribution of trees.

Table 8.16: Oilseeds of tree origin

Oilseeds	Total potential (tonnes)			Availability (tonnes)		Nature of Oil
	Seed	Yield (per cent)	Total Oil production	Seed	Oil	
Mahua	4,90,000	35	1,71,000	71,428	25,000	Hard
Neem	4,18,000	20	83,600	1,00,000	20,000	Semi-hard
Karanj	1,10,000	27	30,000	25,900	7,000	Semi-hard
Kusum	90,000	33	30,000	9,000	3,000	Hard
Sal	55,04,000	12.5	6,88,000	25,000	3,125	Hard
Kokam	2,000	40	800	500	200	Hard
Khakan	46,300	33	15,400			Nut-oil
Nakor	5,700	40	2,300	1,687	675	Semi-hard/ Soft
Undi	3,800	60	2,300			Soft
Total	66,70,800		10,23,400 or 10,00,000	2,33,515	59,000	

If these bottlenecks are removed, a good number of States would be able to: (a) collect large quantities of oilseeds, (b) offer more employment to the tribals and local people, and (c) create greater economic activities in rural areas. Significant possibilities for developing the source for production of minor oilseeds of tree origin in different States are as follows:

Andhra Pradesh — *mahua*, *neem* and *kusum*
Assam — sal, *nahor* and *pisa*
Bihar — *mahua*, *kusum* and sal
Gujarat — *mahua*, *neem* and *pilu*
Karnataka — *mahua*, *neem*, *karanj*, *kokam*, *nahor*, *undi*, *pisa* and *dhupa*
Kerala — *nahor*, *undi*, *pisa* and *dhupa*
Madhya Pradesh — *mahua*, sal, *kusum* and *neem*
Maharashtra — *mahua*, *neem*, *karanj*, *kokam* and *pisa*
Orissa — *mahua*, *kusum* and sal

Rajasthan — *neem*, *pilu*
Tamil Nadu — *neem*, *karanj*, *undi* and *pisa*
Uttar Pradesh — *mahua*, *neem*, sal, *kusum* and *pilu*
West Bengal — *mahua*, *neem*, sal and *kusum*

Besides the above species, there are other forest trees and shrubs, on the seeds of which research and development work is needed. As enumerated by the National Commission on Agriculture these are—*dhak or palas* (*Butea monosperma*), *malkangini* (*Celastrus paniculata*), *kavathi* or *chaulmoogra* (*Hydnocarpus laurifolia*), *bagbherenda* (*Jatropha curcus*), *cherupinnai* (*Calophyllum apetalum*), *arsin-gurgi* (*Garcinia morella*), *phulwara* (*Diploknema butyracea*) (syn. *Madhuca butyracea*), *kamala* or *rohini* (*Mallotus philippensis*), *punnai* or *jangali badam* (*Sterculia foetida*), *pitraj* (*Aphanamixis polystachya*) (syn. *Amoora rohituka*), *kakamari* (*Anamirta cocculus*), *maida lakri* (*Litsea chinensis*), *harra* (*Terminalia chebula*) and *gokhru* (*Xanthium strumariun*). These are not yet being exploited on a commercial scale.

The work of exploiting trees for oil purposes has been mainly done by the Khadi and Village Industries Commission for about 25 years. A Non-edible Oil Seed Association was formed at Poona in 1958. The Khadi Commission has established a centre at Poona to carry out connected research and fabrication of required equipment. The National Commission on Agriculture estimated that the realisable potential of oil production from seeds of various forest trees annually can be of the order of 8 lakh tonnes by 2000 A.D. In the meantime other trees and shrubs mentioned above may be successfully developed for oil production from which source the production may be of the order of 4 lakh tonnes by 2000 A.D., thus making a total of 1.2 m tonnes by 2000 A.D.

Special mention needs to be made of the sal seed potential for oil in India. Sal forests are estimated to cover an area of 11.4 m ha in the various States. The estimated sal area, the estimated potential production of sal seeds, the potential of the quantity of kernel and the actual seed collected during the years 1973-77 are given in Table 8.17.

Sal trees flower in the months of February-March, while its fruits ripen from May to July in different areas. The fruits fall

Table 8.17: Sal seed production 1973-77

Name of State	Sal area (ha)	Estimated production potential (m tonnes)		Actual seed collected (tonnes)				
		Sal seed	Sal seed kernel	1973	1974	1975	1976	1977
Madhya Pradesh	37,68,200	1.9	0.9	30,000	35,000	29,358	8,212	1,03,700
Bihar	33,50,400	1.7	0.8	10,000	1,000	3,000	3,000	10,000
Orissa	28,73,300	1.4	0.7	8,812	10,096	31,365	7,639	45,365
Uttar Pradesh	5,76,800	0.3	0.14	—	—	—	—	11,350
West Bengal	5,23,200	0.25	0.13	—	1,000	1,400	2,000	2,100
Assam	2,70,900	0.13	—	—	—	—	—	—
Total				48,812	47,096	65,129	20,851	1,72,515

to the ground when they are ripe. The fruits have four to five leaves, which act as a wing and the kernel is covered by a green-brown shell. About 500 seeds make 1 kg. The season for sal seed collection starts from about middle of May and lasts for about three or four weeks. The fruits collected from the forests are brought to a central place where they are spread out for drying in the sun for a couple of days. Ordinarily the kernels are separated from the shells by the collectors and then brought for sale.

Madhya Pradesh has nationalised the sal seed trade. Starting from a modest collection of 2,000 tonnes in 1968, the collection of sal seeds in Madhya Pradesh increased to 60,000 tonnes in 1972 and was 1,03,700 tonnes in 1977. There are lean and bumper years in sal seeds. In Orissa, 13 Forest Divisions stand leased out to Messrs Utkal Contractors and Joinery Pvt. Ltd. for a period of 10 years for collection of sal seed and processing it locally within the State. To run the industry the management has established economic and emotional bonds with the seed collectors with whose co-operation it has been possible to achieve record collections. Remaining 12 forest divisions in Orissa are leased out to the Orissa Forest Corporation and Tribal Development Co-operative Corporation, the performance of both of which has also been excellent.

The price of sal seed in the open market has increased over the years. During 1975, the prices ranged between Rs. 675 to Rs. 915 per tonne. In 1976, they varied between Rs. 800 to Rs. 1,350 a tonne, and in 1977 the price range was between Rs. 600 to Rs. 1,100 a tonne. It may be noted that from the point of view of supply of sal seed 1975 was a normal year, 1976 was a drought year and 1977 was a bumper year. It is easy to see the influence of fluctuation in supply on price behaviour.

Collection of sal as also other forest oil seeds provides large employment in the season of collection. Sal-seed oil is also an export product at present and such exports to various countries specially to Japan, Bulgaria, Denmark and Netherlands fetched Rs. 24.4 crores in 1976-77.

ESSENTIAL OILS

In 1972-73, India produced about 1,475 tonnes of essential oils, of which 420 tonnes were exported, remaining being utilised in the country in soap, detergent, perfumes, cosmetics, pharmaceuticals and fine chemical industries. In addition, about 480 tonnes of essential oils were imported that year to meet the demand of the indigenous industry.

The total consumption of essential oils in the various industries in the country is thus estimated to be about 1,550 tonnes. Among the important essential oils is the Indian sandalwood oil. This oil is obtained by distillation of heartwood of sandal (*Santalum album*), an evergreen parasitic tree. The important sandalwood producing States are Karnataka, Tamil Nadu and Andhra Pradesh and, to a lesser extent, Kerala. The total quantity of sandalwood produced annually by these States is about 4,200 tonnes of which Karnataka produces about 2,400 tonnes, Tamil Nadu 1,000 tonnes and Andhra Pradesh and Kerala 400 tonnes each.

On account of ineffective law, considerable quantities of sandalwood are feared to be smuggled to large number of private distillers in Tamil Nadu, Andhra Pradesh, Kerala, Gujarat and Uttar Pradesh. Large-scale release and clearance of land in dry deciduous and scrub forests in recent years has adversely affected the sandal resources. Natural regeneration of sandal occurs by dispersal of seeds by birds, but the rodents eat away the seeds and goats browse young seedlings. Artificial regeneration is generally adopted in forest areas. The cultivators and private individuals are also encouraged to plant sandal. Protection from grazing is the main problem.

Heavy mortality of sandal trees due to spike disease is one of the main bottlenecks for increasing the production of sandalwood. The branches of affected trees produce smaller leaves giving the twigs the appearance of a spike. The sandal spike disease has been the subject of research for a long time, and divergent views exist as to the nature of the disease.

Besides sandalwood oil, the other essential oils of forest origin are lemon grass (*Cymbopogon flexuosus*), rusa or palmarosa (*C. martinii*) and eucalyptus oils. Regarding Eucalyptus, the rights of collection of leaves of blue gum (*Eucalyptus globulus*) are auctioned annually. The method of distillation is at present crude and is mainly a cottage industry. The leaves of *Eucalyptus globulus* fetched a price of over Rs. 200 per ha in 1974. Oil from the leaves of *Eucalyptus citriodora* is also produced. In 1974, Karnataka had nearly 4,000 ha of *Eucalyptus citriodora* plantation of different age classes. The species is pollarded almost annually and maintained as a bush. In 1974, the oil fetched a price of Rs. 70 per kg.

Lemon grass and rusa grass are utilised for the production of essential oils in western Madhya Pradesh and eastern Maharashtra, and *khus* or vetiver (*Vetiveria zizanioides*) in eastern Rajasthan. The oil production can be increased by tying up industrial utilisation with cultivation. Considerable work has been done on the cultivation of the Java variety of citronella grass (*Cymbopogon nardus*), which is high yielding and remunerative. Large scale plantation of this species needs to be undertaken and the development of industries based on this encouraged. Intensive research on this essential oil is already being undertaken by the Central Indian Medicinal and Aromatic Plant Organisation under the Council of Scientific and Industrial Research.

There is good future of linaloe (*Bursera penicillata*) (Syn. B. *delpechiana*). There are nearly 120 ha of private *Bursera* plantations, and 800 ha of Government plantations of this species in Karnataka. The oil fetched nearly Rs. 150 per kg in 1974. The export of essential oils fetched an amount of Rs. 4.67 crores being the average for the years 1971-72 to 1973-74, including an amount of Rs. 2.97 crores from sandalwood oil and Rs. 1.27 crores from lemon grass oil.

TANS AND DYES

A large number of vegetable tanning materials is obtained from the forests. The chief vegetable tan stuffs are the myrabolan nuts, barks of wattle, *Acacia mearnsii* and A. *decuarens*, babul (*Acacia nilotica*) and avaram (*Cassia auriculata*). Apart from these a number of other tanning materials are used by the cottage and small scale tanneries all over the country such as karada (*Cleistanthus collinus*) bark, sal bark, *sain* or *saja* (*Terminalia alata*) (syn. *T. tomentosa*) bark, *dhaura* (*Anogeissus latifolia*) leaves and bark, *ghatber* or *ghont* (*Zizyphus xylopyrus*) fruits, *amla* (*Emblica Officinalis*), *arjuna* (*T. arjuna*) bark, *amaltas* or *sunari* (*Cassia fistula*) bark and *karonda* (*Carissa spinarum*) leaves etc.

Among the important tanning materials are the myrabolans-*Harra* (*terminalia chebula*) and *bahera* (*T. bellirica*). Among these the first is more important. *Harra* is a large deciduous tree. The maximum supplies of chebulic myrabolan come from Madhya Pradesh and small quantities from Orissa, Maharashtra, Bihar, Andhra Pradesh, Tamil Nadu and Karnataka. The nut is used in the form of an extract or in crushed form.

India's demand for vegetable tanning extracts in the organised sector of tanning industry is estimated at 50,000 tonnes, whereas unorganised and cottage sector require another 70,000 tonnes of such extracts per annum. In 1976-77, India imported tanning material worth about Rs. 8 crores, imports having more than doubled over a period of five years. The requirements of tanning materials are likely to increase with special emphasis on tanning leather on an increasing scale in the country itself. According to Tewari (1980), the annual availability of important tanning materials in the country is as follows:

	Tonnes
Myrobalan nuts	1,00,000
Wattle bark	10,000
Babul bark	1,50,000
Asna, Mangrove, *Avaram*, *Konnam* bark	2,50,000

Tanning materials can be conveniently classified for purposes of detailed study into—(i) wood tans; (ii) bark tans; (iii) fruit tans and (iv) leaf tans. Bark tans and fruit tans are of almost equal importance in this country.

MYROBALANS

The best time for collection of *harra* fruits from the point of tanning content is January, fruits collected later or earlier being considered inferior. The average tanning content of a good commercial sample is 32 per cent; however, it may be as low as 12 per cent in inferior qualities in some localities and can go as high as 49 per cent for the best quality ones from the Salem area in Tamil Nadu. The FRI estimated the annual collection of *harra* fruits in 1967 as shown in Table 8.18.

It is essential that a proper survey of *harra* bearing areas including the total number of trees of different age classes and the estimated yield of fruits per tree is made.

Table 8.18: FRI estimate of annual collection of *harra* fruit, 1967

State	Estimated average annual collection (tonnes)
Madhya Pradesh	65,000
Orissa	20,500
Maharashtra	10,000
Bihar	4,000
Andhra Pradesh	3,000
Others	5,000
Total	1,07,500

Myrobalans produce a brownish coloured deposit on leather called bloom. Myrobalan tan is not very astringent and penetrates the hide slowly. When used alone, it produces a rather spongy leather which lacks good wearing properties. It is, therefore, common practice to blend it with other astringents which are quickly penetrating like qubracho and wattle. This neutralises the red colour of leather and produces a more satisfactory tinge. Many tanners regard wattles as an ideal tanning material which has not so far been replaced. The requirement of wattle extract is to the tune of 18,000–20,000 tonnes per year while the production of this material by the only factory producing this in India has not exceeded 3,000 tonnes per annum.

Collection of *harra* fruits in Madhya Pradesh started from 23,500 tonnes in 1970-71 to 52,000 tonnes in 1971-72, but dropping to as low as 5,300 tonnes in 1974-75 and again picking up to 12,700 tonnes in 1977-78. In Madhya Pradesh myrobalan trade has been nationalised with effect from 1969 and improvement has been effected from 1976-77 by the implementation of the agent-purchaser system.

Table 8.19 gives the composition of some of the tanning bearing materials of India that can be used for the manufacture of blended extracts.

It may be mentioned that blended extracts such as babul-myrab, cashew-myrab and modification of myrab tannin nucleus

Table 8.19: Composition of some tanning bearing materials in India

Material	Total solubles (per cent)		pH	Ratio of tan to non-tan	Type of tannin	Yield (per cent)
	Tan	Non-tan				
Myrobalan nuts	25-38	10-17	3.2-3.6	2:5	hydrolysable	35-40
Sal bark	7-12	6-10	5.3-5.5	1:2	condensed	17-18
Karada bark	20-30	8-16	4.1-5.3	2:1	condensed	35-38
Saja bark	16-25	5-8	4.6-4.7	1:8	condensed	24-30
Amla leaves	17-21	16-20	3.5-4.0	1:1	hydrolysable	36-37
Dhaura leaves	12-22	11-18	4.6-4.8	1:1	hydrolysable	30-35
Ghont fruits	8-12	14-18	4.4-5.2	0:5	hydrolysable	24-25
Babul bark	9-19	9-16	4.7-5.5	1:2	mixed and/or condensed	NA

with certain chemicals and synthetic tannis have stood the users' test, as explored by the Central Leather Research Institute, Madras. The myrab extract factory at Kolhapur, Maharashtra is already producing babul-myrab for export trade. Three new tanning extraction plants have been recently established in Madhya Pradesh at Mandla, Raipur and Jagdalpur.

Co-operative efforts

As a help to the tribals, Madhya Pradesh Tribal Co-operative Development Federation (MPTCDF) during 1978-79 was allowed to organise *harra* fruit collection in selected 23 units. The Girijan Co-operative Corporation, Visakhapatnam has got a monopoly of collection of *harra* all over the Andhra Pradesh State. In Gujarat it has been decided that all non-wood products from 14 forest divisions shall be collected by the Gujarat State Forest Development Corporation from the year 1980-81. The Kerala State Pharmaceutical Corporation procures and carries out marketing of *harra* in the Kerala State. In Maharashtra also, the Tribal Development Corporation organises procurement and marketing of this product.

KATHA AND CUTCH

Katha and cutch are produced from the heartwood of *khair* trees which occur naturally in many States in India. The important producing States of *khair* trees are—Andhra Pradesh, Gujarat, Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh and West Bengal. *Katha* is a pale brown product rich in catechin. It is used in *paan* (betel-leaf). Cutch is a dark-brown product rich in catechu tannic essense, has preservative properties and is used for dyeing canvass, fishing nets, mail bags and sail clothes, and also used as a boiler compound and in drilling operations. The annual production of *katha* and cutch was estimated by the National Commission on Agriculture as between 7,000 and 9,000 tonnes of which about 300 tonnes are exported and the rest consumed internally. Tiwari (1980), estimates that out of 63,000 tonnes of khairwood consumed annually by the *katha* and cutch industry in the country, about 30,000 tonnes comes from Uttar Pradesh. The average rates for sale of *katha* and cutch in 1980 were estimated to be Rs. 60,000 and Rs. 5,000 per tonne respectively. Both the products are in great demand and it is essential that their production be increased, by developing more *khair* plantations and establishing new *katha* factories.

The yield of *katha* and cutch varies considerably, with girth and age of trees and also the season of extraction. Maximum yields of *katha* are obtained from trees felled in autumn and winter. Trees that are gnarled and creviced are reported to give higher yields than straight ones. The yield from freshly felled trees is higher.

Table 8.20 gives the yields of *katha* and cutch from heartwood of different States.

Katha is manufactured by the modern factory process as also by the primitive system. In the latter, however, cutch is lost.

Table 8.20: Yields of *katha* and cutch from Khairwood

State	*Katha*	Cutch
Andhra Pradesh	2	3
Maharashtra	3-4 4-5*	10 12*
Madhya Pradesh	3 1.5-1.7*	— 10-12*
Uttar Pradesh	4.5*	10.5*
West Bengal	6.3	—

*Relate to factory production

From this point of view it is desirable that the entire utilisation of *khair* trees is made by the modern factory process.

PINE RESIN

A very important resin is obtained from tapping the *chir* pine (*Pinus roxburghii*) and *kail* or blue pine (*P. wallichiana*) trees occurring in the Himalayan forests. It is an important forest industry. Pine trees are regularly tapped, making blazes which are freshened every week over a period of eight or nine months, the resin being collected in earthen or tin pots fixed at the bottom of the channel on the tree. The States which are concerned with the production of pine resin are Uttar Pradesh, Himachal Pradesh, and Jammu and Kashmir. The total production of crude resin in the three States during the period 1961-70 is given in Table 8.21.

Table 8.21: Total production of crude resin in H.P., U.P. and Jammu and Kashmir in 1961-70

Year	Production of crude resin (tonnes)
1961-62	30,268
1965-66	40,028
1969-70	41,716

The production in these States in recent years has been as follows (Table 8.22):

Table 8.22: Total production of crude resin in H.P., U.P. and J & K in 1970-81

	Resin production in quintals		
	H.P.	U.P.	Jammu & Kashmir
1970-71	1,43,905	NA*	NA*
1971-72	1,42,706	NA*	NA*
1972-73	1,71,326	NA*	NA*
1973-74	1,72,945	3,43,177	NA*
1974-75	1,61,313	3,71,833	NA*
1975-76	1,03,960	2,45,669	NA*
1976-77	1,27,547	2,09,792	NA*
1977-78	1,24,840	1,52,439	NA*
1978-79	80,100	1,28,457	NA*
1979-80	75,146	1,44,745	NA*
1980-81	76,568	1,70,188	NA*

*NA=Figures not available

The National Commission on Agriculture in their report in 1976 estimated that if processing facilities in Government factories are augmented, products are diversified and exports are increased, the production may be stepped up to 1,00,000 tonnes by 1985 and 1,50,000 tonnes by 2000 A.D. Unfortunately, the production of resin has dropped steeply during the last ten years due to wrong tapping methods over a period of time which virtually amounted to eating into the capital, also resulting in serious injury to pine forests. The tapping operations provide large-scale employment and are a major source of sustenance to the local people.

The processing of resin is done mainly by the four Government factories, whose installed capacities are as follows:

	Tonnes
Indian Turpentine & Rosin Co. Ltd., Bareilly	20,256
Government Rosin & Turpentine Factory, Nahan	3,700
Government Rosin & Turpentine Factory, Bilaspur	7,400
Government Rosin & Turpentine Factory, Jammu	2,500
Total	33,856

The important products of resin obtained by distillation are rosin about 80 per cent and turpentine about 17 per cent. Rosin is used in the manufacture of paper and other derivatives. Turpentine is used in a large number of chemical industries like estergum, rubber, emulsifiers, camphor, varnish, phenyl, etc.

GUMS

Certain valuable gums are extracted in India's forests which ooze out from the trees either naturally or on making artificial incision, known as exudate gums. Technically, the term refers to plant polysaccharides or their derivatives which are dispersible in either cold or hot water, to produce viscous mixtures or solution. All gums are not soluble in water. Some of them merely swell up in water and form a sort of gel, while others are completely soluble.

The important Indian gums of commerce are *jhingan* (from *Lannea coromandelica*), Malabar *kino* (from *Pterocarpus marsupium*), Bengal *kino* (from *Butea monosperma*), *katira* (from *Cochlospermum religiosum*), *ghatti* (from *Anogeissus latifolia*), and gum arabic from *babul* trees *(Acacia nilotica*). True gum arabic is obtained from *Acacia senegal* in which Sudan has a world monopoly. The most important of all the Indian gums is, however, gum *karaya* obtained from *Sterculia urens* and S. *villosa*, both trees of dry deciduous forests. Gum *karaya* is important for pharmaceutical industries, both for industrial consumption and for export. Its chief producing States are Madhya Pradesh, Uttar Pradesh, Rajasthan and Gujarat.

The formation of gums is believed to be the result of disintegration of plant tissues. The method of tapping is so devised that regular supply of gum is assured without causing damage to the trees. The gums ooze out from the plants in liquid form and dry up into amorphous tear shaped bodies on exposure to the atmosphere.

Generally trees above 90 cm or more in girth at breast height are tapped. Rectangular blazes 10 × 15 cm are prescribed which are freshened upwards at fortnightly intervals extending by 4 cm with each freshening. A fairly good average is 1 kg/tree/season. At present about 5,000-6,000 tonnes of gum *karaya* is produced annually in the country although the potential is far greater than this. The exports during the period 1967-68 to 1976-77 averaged about 5,000 tonnes, valued at Rs. 4.5 crores in 1976-77. Gum *karaya* is widely used in food, confectionary, textiles and pharmaceutical industries. Lower grades are used in varnishes, lacquers, inks, linoleum, oil cloth, etc.

DRUGS, SPICES AND INSECTICIDES

Out of about 2,000 items of drugs recorded in the *Indian Materia Medica*, over 1,800 are of vegetable origin. About 128 of these are recognised in the Indian and British Pharmacopoeia. Quite a few of these are obtainable from the forests. Drugs are derived from fruits, flowers, leaves, stems or roots of trees, shrubs, creepers and herbs. They are administered as solids, liquids, infusion or dust. Of the drugs from roots, mention may be made of *ipecac* from *Cephaelis ipecacuanha*, *liquorice* from *Glycyrrhiza glabra*, Indian *sarsaparilla* obtained from *anantmul* (*Hemidesmus indicus*), *sarpagandha* from *Rauvolfia serpentina* and *kuth* from *Saussurea lappa*.

Rauvolfia serpentina is a small plant growing sporadically in the sub-Himalayan tract and in the plains near the foothills and also in the Western Ghats and elsewhere. A drug is obtained from the wood of *Ephedra* spp., a small xerophytic plant found in dry places on rocks in the Himalayas above an elevation of 2,400 metres. Drugs are obtained from the leaves of *senna* (*Cassia augustifolia*) and *chiretta* (*Swertia chirata*). *Senna* is a small plant of Southern India. Its pods are also used for drugs. *Chiretta* is a small erect perennial herb or shrub of the temperate Himalayas at an elevation from 1,200 to 3,000 metres and of the Khasi hills.

The NCA in 1976 estimated the approximate requirements by 1985 of some of the important types of vegetable drugs as shown in Table 8.23.

Table 8.23: Approximate requirement of vegetable drugs by 1984

Name of Product	Part/s used	Approximate requirements in 1985 (tonnes)
Aconite	roots	203
Indian belladona (*Atropa acuminata*)	roots	300
Datura (*Daturainn oxia* and *D. metel*)	Leaves and flowers	40
Dioscorea deltoidea	tubers	1,500
Ephedra	aerial parts	75
Podophyllum	rhizomes and roots	150
Sarpagandha	roots	1,600
Nux-vomica	seeds	2,000
Ipecac	roots	50
Indian squil (*Urginea indica*)	bulbs	50

A good number of spices are collected from the forests. *Kala jira*, seed of *Carum carvi* is a much valued spice because of its strong agreeable flavour. It is also a stomachic, carminative and lactagogue. The spices occur naturally in certain temperate forests.

Galanga is obtained from *Alpinia galanga*, a plant found in the Eastern Himalayas and in the Western Ghats. It has perennial rhizomes which are aromatic and pungent. Cinnamon or *dalchini* is the bark of *Cinnamomum zeylanicum*, a tree of the Western Ghats from Konkan southwards found up to an elevation of 1,800 metres. It is astringent, stimulant and carminative, also used in candy, gums, incense, and perfumes. It has a delicate fragrance and sweet agreeable taste.

Other products used as spices are *Elaichi chhoti* or lesser cardamom which are the dried capsules of *Ellettaria cardamomum*, and *Elaichi badi* which are the pods of *Amomum subulatum*, *tejpat* which are the leaves of *Cinnamomum tamala*, besides insecticide pyrethrum (*Chrysanthemum cineraerafelium*).

LAC

Lac is the resinous protective secretion of the tiny lac insect *Laccifer lacca*. The minute red coloured larvae of the insect settle on young shoots of the host plants in myriads. The secretions from individual insects coalesce and form a hard continuous encrustation over the twigs. After the completion of the life cycle and just about the time the adults of the next generation begin to emerge, the resinous encrustation is scraped from the twigs and branches of host trees, giving what is called sticklac. Shellac is obtained by either melting or by extracting the resins by solvents from seedlac.

Lac finds a wide variety of application in plastics, electricals, adhesives, leather and wood finishing, printing ink and other industries. It is also the principal ingredient of sealing wax. Its main use at one time was in the manufacture of gramophone records, which declined recently due to the introduction of synthetic materials.

Lac cultivation is done by about three million *adivasi* cultivators. It is primarily grown in Chhota Nagpur and Santhal Parganas of Bihar, Purulia and Bankura districts of West Bengal, eastern parts of Madhya Pradesh and Uttar Pradesh, Bhandara and Chanda districts of Maharashtra, and Keonjhar, Mayurbhanj and Sundergarh districts of Orissa.

The average annual production in the 1950s and 1960s is given in Table 8.24.

Table 8.24: Average annual production (tonnes) of sticklac in different states

Name of State	Average for 1951-60	Average for 1961-62 to 1965-66	Average for 1966-67 to 1970-71
Bihar	17,341	13,334	17,185
Madhya Pradesh	13,019	6,818	6,099
West Bengal	6,580	3,948	2,754
Uttar Pradesh	657	1,723	1,955
Other States	3,889	4,194	1,676
Total	41,486	30,017	29,669

The production during the years 1970-71 to 1973-74 is given in Table 8.25.

Table 8.25: Lac production during 1970-74

Year	Production tonnes
1970-71	24,560
1971-72	27,211
1972-73	17,038
1973-74	19,258

India had a virtual monopoly of lac and till about 1950 accounted for nearly 85 per cent of the world's production of sticklac. In 1950, however, Thailand produced about 25–35 per cent of the world's requirements.

Two strains of the lac insect are commonly recognised in India, *rangeeni* and *kusumi*, lac crops raised from them being named after the months in which they are harvested. As much as 80-90 per cent of the country's production is from *Rangeeni* crop. This crop is harvested in the month of October-November from the inoculations made in June-July, and again in June-July from inoculations made in October-November. The selection of host trees is vital. Trees should be quick growing, adaptable to pollarding and able to withstand heavy infestation of the lac insect. There are well over 100 species of plants on which the lac insect has been recorded, but the major hosts are—*palas* or *dhak* and *ber* (*zizyphus* spp.) in the case of *rangeeni* strain and *kusum* in the case of *kusumi* strain. Bulk of lac production is from the above hosts. There are some other hosts also. For instance, *khair* is a good host plant for growing the *katki* or *aghani* crop in alternation with the normal *rangeeni* or *kusumi* hosts. Several *Ficus* species are used for growing the *baisakhi* crop which attains maturity with comparatively much less mortality, but these trees are used more for the sake of preserving broodlac than for raising lac as a commercial crop.

The proper management of the host plants, use of pest-free brood, time and manner of inoculating host plants, and control of pests and predators of the lac insect are important factors for the success in lac culture.

The marketing arrangements at present are primitive. The cultivators harvest the lac crop and bring it in headloads to the nearest village market. The product goes through a number of intermediaries. As much as 80-90 per cent of the product is exported. In 1979-80, about 11,000 tonnes were exported fetching an amount of Rs. 11.13 crores in export earnings.

Tasar

Tasar insects are cultivated on the leaves of *arjun* trees (*Terminalia arjuna*).

EDIBLE FRUITS

Forests supply large number of edible fruits, which occur naturally and are being increasingly cultivated in forest areas now. Among the important of these is tamarind which occurs sporadically in the forest areas in South India and is now cultivated with *Kumri* method in Tamil Nadu. Practically every part of the tree is useful to man and his animals. The timber is hard and close-grained and is used for rice-pounders, wheels etc. The firewood makes an excellent charcoal. Tender leaves and parts of flowers are eaten and used in the preparation of salads, curries and soups. They are also used for medicinal preparations. The leaves, flowers and fruits are used as ancillaries in dyeing. Fresh juice of tender leaves is useful in bilious fever. The bark and seed husk are valuable tanning materials.

Of course, the fruit is the most valuable portion. The pulp consists of about 71 per cent carbohydrates and 3 per cent protein. The dried pulp is exported from India to Europe and America for the preparation of *chutneys* and meat sauces.

The pulp of the fruit is antiscorbutic, digestive, carminative, cathartic, laxative, astringent, febrifuge, refrigerant and antiseptic. It is given in habitual costiveness, alcoholic intoxication, *dhatura* poisoning, bilious vomiting, febrile disorders and dysentery and also for preventing and curing scurvy. The pulp is usually given alone or mixed with lime juice, honey, etc., in about half-ounce doses. It is an excellent corrective of bilious disorders when given in three drachms to the ounce doses; this dose is enough to render the pulp moderately cathartic.

The seed contains 63 per cent starch, 16 per cent proteins and about 5 per cent semi-drying oil. They can be eaten after removal of the testa and roasting or boiling. They are also made into flour. Due to their high carbohydrate content, they are used for sizing cloth, country-made blankets, paper and jute products and for vegetable gum in the food processing industry. They are also used as adulterant to coffee powder. They are used in jam and jelly industries. From the seeds is extracted an amber coloured oil which is processed to be used as a varnish for painting idols and images. The finely ground flour can be mixed with glue and used as a strong wool cement.

Among the other fruit trees from the forests are *Ber* (*Zizyphus jujba*), Cashew apple (*Anacardium occidentale*), *Amla* (*Emblica officinalis*), mango, *seethapalam* (*Annona squamosa*) and jackfruit (*Artocarpus integrifolia*).

Cashew plantations are being raised on an extensive scale in forest areas including some by the forest development corporations.

Clove

The cloves of commercial importance are the dried unopened flower buds of *Cinnamomum zeylanicum* which plantations are being raised in Kanyakumari district of Tamil Nadu and are extremely remunerative.

Mahua

Mahua (*Madhuca latifolia*) is one of the most important trees of India in many regions, specially in tribal areas. Its use as edible oil has been discussed earlier. The sweet flowers are dried and powdered to make chapatis, and form an important part of food in tribal regions. Grafted *mahua* and tamarind deserve to be planted in forest areas extensively, especially near villages.

CHAPTER 9

Energy Position, Social Forestry and Agro-forestry

Energy position in India

India, in common with many developing countries, consumes energy in a variety of forms ranging from electricity obtained from nuclear fuels, hydro-power, oil, and the non-commercial sources of energy like fuelwood, agricultural wastes and animal dung. The total consumption of commercial and non-commercial forms of energy in India during the years 1953-54 to 1978-79 as estimated in the Report of the Working Group on Energy Policy of the Planning Commission, 1979 is given in Table 9.1.

Table 9.1: Consumption of commercial and non-commercial forms of energy 1953-54 to 1978-79 (Million tonnes of coal replacement=MTCR)

Sources	1953-54	1960-61	1965-66	1970-71	1975-76	1978-79
Total Commercial Energy	60.4	101.2	147.0	197.3	252.7	294.3
*Total Non-Commercial Energy	125.9	145.5	159.6	172.2	194.6	198.0
Total	186.3	246.7	306.6	369.5	447.3	492.3

**Note*: The contribution from draught animals is not included.

Allowing for a 70 per cent increase in population of the country from 1953-54 to 1978-79, the per capita consumption of energy in India during the period 1953-54 to 1978-79 increased by about 56 per cent. Its very uneven distribution is, of course, another vital matter. A basic problem of development in India is the development of energy sources. The low level of energy consumption is directly linked to inadequate development in the country. As Roger Revelle (1976) has pointed out: "The men and women of rural India are tied to poverty and misery because they use too little energy and use it inefficiently, and nearly all they use is secured by their own physical efforts. A transformation of rural Indian society could be brought about by increasing the quantity and improving the technology of energy use".

While development of commercial sources of energy is no doubt being attempted on large scale commensurate with the national resources, in the words of the Energy Policy Working Group referred to above "a peculiar aspect of the Indian energy scene is the substantial share of non-commercial energy . . . this is likely to be a permanent feature of the economy and every effort should be made to better manage or commercialise these so-called non-commercial and renewable sources of energy so that they can by used more efficiently. Unless the problem is adequately resolved, the energy problem of the rural sector, where it is most critical, is unlikely to be solved and alleviation of rural poverty is nearly impossible".

Future demand of energy

According to the report of the Working Group on Energy Policy, 1979, the future demand of energy in the years 1987-88 and 2000-2001 is given in Table 9.2.

The share of commercial energy in different sectors in the years 1978-79 as per the above Report is given in Table 9.3.

The consumption of non-commercial energy during the years 1953-54 to 1975-76 as estimated by the above Working Group is given in Table 9.4.

As would be seen, fuelwood forms a major source of non-commercial energy in India and the requirement has been increasing rapidly.

Table 9.2: Consumption and future demand of energy based on optimum level forecast (MTCR)

Fuel	Consumption 1978-79	Future demand 1987-88	Future demand 2000-2001
Coal**	68.8	128.0	265.0
Oil Products*	141.1	197.6	356.2
Electricity	84.4	173.6	395.6
Total Commercial Energy	294.3	499.2	1,017.8
Non-Commercial Energy	198.0	202.8	163.5
Total Energy	492.3	702.0	1,181.3

*Excludes fuel oil used for power generation.

**Excludes coal used for power generation.

Table 9.3: Share of different sectors in the consumption of commercial energy in 1978-79

Sector	Consumption of commercial energy				
	Absolute (MTCR)	Percentage of total	Relative share (%)		
			Coal	Oil	Electricity
Household	40.3	13.7	10.0	71.2	18.8
Agriculture	31.3	10.6	—	61.8	38.2
Industry	113.4	38.5	44.5	7.9	47.6
Transport	93.2	31.7	13.3	83.9	2.8
Others	16.1	5.5	11.9	36.2	51.9
Total	294.3	100.0	23.4	47.9	28.7

Production of agricultural wastes

The production of agricultural wastes or agricultural residues in 1975-76 according to the above report is given in Table 9.5.

It would be seen that out of an estimated production of 203 m tonnes of agricultural wastes, 41 m tonnes was estimated to

Table 9.4: Consumption of non-commercial energy 1953-54 to 1975-76

Year	Fuelwood		Agricultural waste		Animal dung		Total MTCR
	M.T.	MTCR	M.T.	MTCR	M.T.	MTCR	
1953-54	86.3	82.2	26.4	25.1	46.4	18.6	125.9
1960-61	99.6	94.6	30.6	29.1	54.6	21.9	145.5
1965-66	109.3	103.8	33.6	31.9	59.9	23.9	159.6
1970-71	117.9	112.0	36.3	34.4	64.6	25.8	172.2
1975-76	133.1	126.5	41.0	38.9	73.0	29.2	194.6

M.T. = m tonnes.

Table 9.5: Production of agricultural wastes or residues

Description	Area ('000 ha)	Production ('000 tonnes)	Agricultural wastes ('000 tonnes) (Estimated)
Rice	39,475	48,740	77,984
Wheat	20,454	28,846	50,480
Maize	6,031	7,256	8,707
Cotton	7,350	1,012	3,036
Jute	584	755	1,510
Barley	2,802	3,192	4,788
Other minor crops	67,422	36,157	28,926
Sugarcane	2,762	1,40,604	28,121
Total			2,03,552

have been used in 1975-76 as fuel. Further, animal dung forms 15 per cent of the total energy consumption in the rural sector. Out of the total estimated production of 324 m tonnes of animal dung (air dry), about 73 m tonnes is estimated to be burnt for energy purposes. One could say that animal dung burnt in 1975-76 for energy purposes was more than the total fertiliser consumed in agricultural production in India. Obviously, if animal dung is used as fertiliser in many areas, the food production can be augmented substantially.

Social forestry

Farm forestry has been defined by the National Commission on Agriculture as the practice of forestry in all its aspects on farms or village lands generally integrated with other farm operations. However, what was actually practised may possibly be better termed as extension forestry with farm forestry as its integral part. It included the activity of raising trees on farm lands, village wastelands and community forest areas. The National Commission on Agriculture furnished an interim report on social forestry in 1972 in which the Commission stressed the socio-economic importance of social forestry in the rural community as well as in the management of forestry resources. According to the Commission, the scope for social forestry programme was defined to include farm forestry, extension forestry, reforestation in degraded forests and recreation forests. According to the FAO document on 'Forestry for Local Community Development' (1978), community forestry which is much the same as social forestry is any situation which intimately involves local people in the forestry activity. It embraces a spectrum of situation ranging from woodlots in areas which are short of wood and other forest products for local needs, to the creating of trees at the farm level to provide cash crops and the processing of forest products at the household, artisan or small industrial level to generate income to the activities of forest dwelling communities. It excludes large-scale industrial forestry and any other form of forestry which contributes to community development solely through employment and wages, but it does include activities of forest industrial enterprises and public forest services which encourage and assist forestry activities at the community level. The activities so encompassed are potentially compatible with all types of land ownership. While it thus provides only a partial view of the impact of forestry on rural development, it embraces most of the ways in which the goods and services of forestry directly affect the lives of rural people.

In this connection, the observations of K.F.S. King, Assistant DG, and Representative of the Forestry Department of the

FAO in his foreword to the above publication deserve attention.

"Forestry for Local community Development is a new people-oriented policy adopted by FAO, the objective of which is to raise the standard of living of the rural dweller, to involve him in the decision making processes which affect his very existence and to transform him into a dynamic citizen capable of contributing to a larger range of activities, than he was used to and of which he will be the direct beneficiary. Forestry for Local Community Development is, therefore, about the rural people and for the rural people. Its ultimate objective is not physical but human. The physical goals which will be set are really the means towards achieving the objectives of enchancing the lives of human being. And one of the vehicles which we advocate in order to assist in the achievement of these objectives is forestry".

Production and demand for fuelwood

The analysis by G.R. Gregory of the Ford Foundation referred to in Chapter 8 showed the total fuelwood requirement to be 103 m metre^3 for the year 1970, 13 m metre^3 from the forests and 90 m metre^3 from other tree lands. The total consumption of fuelwood in 1970-71 was estimated to be 117.9 m tonnes by the report of the Fuel Policy Committee.

The consumption of 117.9 m tonnes of fuelwood is equivalent to about 175 m metre^3 of wood. The National Commission on Agriculture assumed 277 metre^3 per thousand persons consumption for 1985 and estimated a consumption of 240 metre^3 per thousand persons for the year 2000. According to this calculation, the total requirement for fuelwood, expressed in m metre^3 was to be or would be as shown in Table 9.6.

As pointed out in a recent article in the *Financial Express* (1983) by Satish Jha, the data base for rural energy in the country is scanty and mostly unreliable. Such surveys by the National Sample Survey Organisation are few and far between, the first such survey was conducted in 1963-64 (18th round of NSS), followed in 1973-74 (28th round), the latest being in 1977-78 for which the data has not been made available so far. Further, the data of such surveys are finally clubbed together under the category of 'fuel and light' and sufficient details of non-commercial energy used are lacking. The National Council of

Table 9.6: Estimated requirement of fuelwood in m metre^3

Year	Quantity of wood
1980	184
1985	202
2000 A.D.	225

Applied Economic Research carried out two surveys in 1962 and 1977 and their data for per capita energy consumption of three non-commercial fuels—firewood, dung cake and vegetable waste is presented in Table 9.7.

Table 9.7: Per capita consumption in kg

	1962 survey	1977 survey
Firewood	237	120
Vegetable waste	28	95
Dung cake	169	158

The serious contradictions in the data are obvious.

The agricultural land in India also contains some trees, the branches of which are lopped by villagers for fuel. Assuming such loppings to be 50 kg per tree per annum, this gives a total quantity of 50 m tonnes of fuelwood per annum in the form of twigs.* It is well known that by far most of the urban population purchases fuelwood in the form of billets or split, while fuelwood overall is not a monetised item in the villages. Apart from wood shavings and saw dust, Bhumbla (1983), estimates the consumption of fuelwood in India by different types as follows, as between rural and urban India (Table 9.8).

The fact of chronic shortage of fuelwood for energy purposes in most parts of India is not doubted and rural people have often to travel greater and greater distances to collect firewood for their essential daily needs.

Photosynthetic pathway

As M.S. Swaminathan in the introduction to the Report of

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*Assuming 10 trees/ha over 100 m ha unirrigated cultivated area.

Table 9.8: Consumption of fuelwood in India by different types (m tonnes)

	Rural	Urban	Total
Logs	20.1	11.5	31.6
Twigs	58.7	4.2	62.9
Total	78.8	15.7	94.5

the Fuelwood Study Committee (1982) of the Planning Commission has pointed out, India is bestowed with abundant sunlight which provides enormous opportunities for harnessing this energy through the photosynthetic pathway of biomass production. India's Sixth Five Year Plan outlined a detailed strategy for self-reliance in the energy sector. The Plan has made a special provision for the establishment of energy plantations and emphasis has been given to harnessing the sources of energy like biomass and biogas especially to meet the energy requirements of rural communities. However, the amount provided is utterly inadequate compared to the gravity of the problem. For an efficient harvest of solar energy throughout the year, it is essential that every available piece of vacant land is covered with annuals as well as perennial trees and shrubs for producing biomass. The biomass can be utilised directly as fuel or can be converted into alcohol, methane, ammonia, etc., through suitable bio-chemical and microbiological conversion methods. The vast panorama of opportunities available in biomass utilisation is just unfolding. Energy plantations based on the cultivation of 'Firewood Crops' should become as sophisticated an art as the cultivation of rice or wheat, wood gasifiers and electric generators.

It is worth mentioning that a host of possibilities are opening up, so far as the prospects offered by the wood energy systems are concerned. In the USA also the Appalachian Wood Energy Development programme has been started for such new conversion technologies. Already several wood manufacturing plants near the Western Carolina Campus have reverted to wood fuel and even to wood-fired steam plants, retaining the conventional oil-fired boilers only as standby.

Table 9.9: Prices of firewood (Rs./100 kg)

State and City	1960	1975	1976	1977	1978*	1979*	1980*	1981*	1983 June	Price relative percentage= $\frac{\text{June 83}}{\text{1960 average}} \times 100$
Haryana										
Yamunanagar	8.3	25.6	26.2	26.2	28.7	32.6	41.2	50.0	65.0	787
Uttar Pradesh										
Saharanpur	5.8	25.0	23.9	23.8	25.0	26.2	35.0	45.0	73.8	1,266
Kanpur	6.1	21.0	21.7	23.1	23.8	26.6	32.9	40.3	52.3	850
Rajasthan										
Ajmer	8.6	26.2	31.1	31.9	31.3	37.5	38.3	43.8	67.2	778
Jaipur	7.8	23.2	27.5	29.9	29.5	31.7	30.9	39.2	62.4	796
Gujarat										
Ahmedabad	9.0	28.3	30.0	30.6	30.5	32.5	36.4	42.5	55.5	617
Bhavnagar	8.0	25.0	25.0	25.0	25.0	25.0	30.0	30.0	35.0	435
Madhya Pradesh										
Bhopal	5.5	19.2	18.3	18.0	18.6	20.3	21.4	33.7	59.2	1,080
Indore	5.7	24.3	23.9	25.3	26.7	26.2	28.8	45.0	60.0	1,052
Maharashtra										
Bombay	8.5	36.1	36.8	36.5	37.1	44.7	47.4	57.8	85.7	1,012
Sholapur	8.9	23.4	26.9	27.6	30.0	37.5	40.9	45.5	62.8	704

Karnataka									
Ammathi	1.9	13.6	14.1	14.1	14.2	14.2	15.2	15.2	20.1	1,058
Bangalore	4.7	21.0	21.4	22.5	23.0	27.8	36.0	40.0	50.0	1,068
Andhra Pradesh										
Hyderabad	6.6	23.2	23.1	23.8	24.3	30.0	32.0	40.3	55.0	429
Gudur	6.9	13.9	13.9	15.9	20.9	26.1	26.1	26.1	29.6	833
Tamil Nadu										
Coimbatore	7.3	22.1	23.2	24.3	36.5	31.2	39.5	47.0	60.0	822
Madras	8.2	25.4	25.4	28.1	33.1	40.4	46.6	52.0 40.6	59.1	716

*Mid-year prices, June.

The feasibility of using producer gas on a large scale has been amply demonstrated. Even at the end of Second World War, there were close to five million vehicles in Europe running on producer gas. The Philippines in recent years have developed large-scale producer gas units for water pumps, automobiles, boats and electric generators. China is also using tractors, run on producer gas from fuelwood burning. Messrs Jyoti Ltd. of Baroda have already developed engines run on 80 per cent producer gas from biomass, and may soon develop 100 per cent producer gas run engines for agricultural use.

Technically speaking, there are several generic approaches to wood conversion: pyrolysis, gasification, hydrogenation, enzymatic hydrolysis followed by fermentation and anaerobic digestion. The World Bank Report *Energy in the Developing Countries* (1980) makes a special mention of liquid and gaseous fuels from biomass as holding considerable promise for application and development in the less developed countries.

Fuelwood prices

On account of the fact that production of fuelwood has not been able to keep pace with the requirements, the prices of fuelwood during the last 20 years in India have shown an abnormally high increase. Table 9.9 gives the prices of fuelwood at a number of selected centres during the years 1960 to 1983. The last column in the table shows the percentage increase over the period 1960 to1983 in nominal or current rupees. The all-India consumer price index over the same period stood at about 450 in 1982 compared to 1960. Thus, in all but two cases, fuelwood prices increased more than the consumer price index steeply. In many cases, it can be seen, prices have doubled in the last six years ending June 1983. Because of the increasing costs of petroleum products and the supply constraints, firewood prices can be expected to increase in real terms faster in future, unless positive steps are taken to increase production at a much greater rate than hitherto.

Fuelwood farming

Because of the steeply escalating prices of petroleum products and the rising demands and prices of fuelwood in most parts of the country, a stage has now reached where fuelwoods can be economically farmed, with inputs of selected species and varieties, labour, water, nurseries, fertilisers and pesticides. It may be mentioned that fuelwoods in general have hitherto been usually grown in conjunction with the more valuable part of the tree, viz. the timber and the poles, which position needs to be reviewed in many places.

SUBABUL

One of the promising species for fuelwood production in the tropics is *Leucaena leucocephala (Ku Babul* or *Epil-Epil)* henceforth called *Subabul*, especially, the Hawaiian Giant variety K-8. *Leucaena* is among the fastest growing tree species in tropical and sub-tropical climates, coppices vigorously, fixes nitrogen, is fairly drought resistant, produces a semi-hard wood, with excellent burning properties, has average properties as timber and poles, and its leaves make an excellent high protein (up to 27 per cent crude protein) fodder for livestock. Originally from Central America, the plant has been widely introduced in many tropical countries of the world. As early as 1931, *Subabul* was introduced in the demonstration area of the Forest Research Institute, Dehra Dun. Bharatiya Agro Industries Foundation (BAIF) of Pune has been a pioneer of *leucaena* extension in India over the past ten years, and trials of this important species have been undertaken in most States of the country during the last six years.

According to the United States, National Academy of Sciences (1977), the expected annual yield in Hawaii and Philippines from *Subabul* with a six to eight year rotation is up to 54 tonnes (air dry)/ha, while the average annual yields vary from 15 to 19 ADT/ha (density of six to eight year old wood is 0.54)*. The yield of the Hawaiian Giant at the forest nursery at Clutterbuckganj, Bareilly, U.P. (rainfall 1050 mm) under intensive management and irrigation according to A.N. Chaturvedi comes to 28 ADT. According to L.L. Relwani of BAIF, who has carried out intensive work with *Subabul* at Urulikanchan for several years, the yield of *Subabul* in a 700 mm rainfall area with no irrigation but with fertilisers under a five-year rotation comes to 8 ADT. With one protective irrigation, however, every month from October to May in the first year only, the yield is estimated by Relwani at 50 ADT/ha/annum, which, however, seems to be an estimate on the high side. S. Palit in 1980 estimated for Jalpaiguri and Buxa forest divisions (rainfall 3,310 mm) of West Bengal the *leucaena* annual growth to be about 19 ADT/ha/annum. Brewbaker and Hutton have reported that *Subabul* has yielded in excess of 125 tonnes/ha/annum bone dry weight when harvested at 2.5 years of age in closely spaced plantation of 44,000 plants/ha.

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*All yields or increments of wood in this Chapter are henceforth expressed as air dry tonnes (ADT)/ha/annum.

Recommendations of the Urulikanchan seminar

The seminar on *Subabul* at Urulikanchan held in June 1981 made a number of broad recommendations regarding the establishment of seed orchards of pure genotypes of the best varieties, in respective States, further to evolve a package of nursery techniques and develop a network of co-ordinated studies on comparative performance of *Subabul* vis-a-vis other species and their cultivars, in different agro-ecological zones of the country. It was also recommended that cultural and management practices appropriate to major agro-ecological zones of the country should be developed including age of transplant, different soil working techniques, planting densities, frequency of weeding, fertilisation including liming in the case of acid soils, irrigation regimes, etc.

Difficulties in growing leucaena

A number of papers presented by State Forest Departments at the above Seminar elaborated the difficulties in growing leucaena under forest conditions. The plant is highly palatable, not only to cattle, but also to monkeys and rabbits and the plantations have, therefore, to be protected intensively. *Subabul* suffers from gummosis and a plantation in Uttar Pradesh wherein gummosis was spreading had to be cut down and burnt. The species is also frost tender. In areas, with rainfall less than 500 mm two irrigations per month from October to June in the first year of the formation of the plantations are desirable to obtain optimum growth. In general, tractor ploughing and ridging the entire area in winter prior to plantation is also desirable. For *Subabul* firewood plantation a spacing between 1.8 × 1.8 metre and 1 × 1 metre appears optimal. According to tentative information, in areas of 1,250 mm rainfall with a three to five year rotation, with hand watering during the first year of establishment in the dry period, reasonable soil conditions and effective protection, a mean annual increment of 7-10 ADT/ha could possibly be assumed.

Eucalyptus species

In India, Eucalyptus species was first introduced around 1790 at Nandi Hill near Mysore. Regular trials were started in 1843 at Willington in the Nilgiris, when Captain Cotton successfully introduced *E. globulus.* However, the Nandi grown *E. tereticornis* commonly called Mysore hybrid or Mysore gum or just Nilgiris in some parts of South India has been most commonly planted in varying climatic areas of the country. This species was first raised on a plantation scale in Karnataka in 1952. Large-scale plantations of this species were taken up in Uttar Pradesh from 1962.

As Chaturvedi (1983) records in a highly informative monograph '*Eucalyptus for Farming*' "because of their astonishing growth characteristics, climatic adaptability and wide-ranging usefulness, Eucalypts are increasingly being regarded as amongst the most important trees available for man's exploitation". Though Australian, or more correctly Austro-malayan, the area of commercial eucalyptus plantations today cover more than 4 m ha in 58 countries, while trial planting or ornamental planting is being carried out in another 50 countries, many of whom may soon embark on commercial plantings.

During the course of evolution, the Eucalypts have developed growth characteristics which help them to survive under severe environmental conditions. Between 1961 and 1975 the volume of Eucalyptus wood produced annually in plantations outside Australia had increased to about nine times the volume harvested annually in Australian natural forests. What enables the Eucalypts to become so predominant in difficult sites is their ability to colonise bare ground without shelter. A great majority of Eucalyptus spp. have developed a very effective subterranean protective organ known as a Lignotuber. These enable the trees to produce new shoots, if the aerial part of the plant is destroyed by browsing, fires or other accidents.

According to an estimate made in 1972, a total area of 2.8 lakh ha had been planted under various Eucalyptus species in India up to 1968-69. Till 1974, an estimated 4,15,000 ha of *E. tereticornis* had been planted throughout India. The area planted under Eucalyptus to date can be estimated around 7 to 8 lakh ha. Other species planted are *Eucalyptus globulus* in Nilgiris, and *Eucalyptus grandis* in Kerala. Eucalyptus hybrid has been raised mostly in Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal, Madhya Pradesh, Maharashtra, Gujarat, Andhra Pradesh, Karnataka and Tamil Nadu. Eucalyptus hybrid and *globulus* coppice well when young. *E. globulus* is often considered to be the fastest growing tree in India. Besides wood, it is also an important source of eucalyptus oil.

According to the yield tables on Eucalyptus hybrid compiled by Chaturvedi (1981), the yield for Eucalyptus hybrid in forests under five site conditions/qualities for rotations from six to nine years is given in Table 9.10.

Table 9.10: Eucalyptus hybrid yield

Site quality	Rotation years	No. of stems per ha	ADT/ha/annum
I	6	964	7.9
II	6	1,038	5.1
III	7	1,105	3.0
IV	8	1,202	1.6
V	9	1,345	0.7

(Density of Eucalyptus hybrid wood 0.75)

GUJARAT AND U.P. EXPERIENCE

Kalidas Bhai Patel, a farmer of Gujarat has a farm at Vatava in Ahmedabad district with an area of 79 ha. Starting in 1973, the farm was progressively planted by him with Eucalyptus hybrid at a spacing of 3 × 1 metres with fertilisation and regular irrigation. The mean annual increment put on this farm by Eucalyptus hybrid works out to 25 ADT/ha i.e. about three times the increment for site quality I under forest conditions.

The internal rate of return of this plantation as calculated by B.P. Srivastava and M.M. Pant in 1979 came to 89 per cent.

V.J. Patel, a former Professor of Civil Engineering turned forest farmer and large number of other cultivators have planted Eucalyptus at spacing of 60 cm × 60 cm under intensive fertilisation and irrigation in Bhavanagar and other districts of Gujarat and MAI of up to 75 tonnes/ha has been claimed along with highly profitable returns.

During 1980-81, A.N. Chaturvedi gives the first year raising cost of mechanised plantations in Uttar Pradesh tarai areas as shown in Table 9.11.

According to Chaturvedi, a review of expenditure and yield of plantations raised in Uttar Pradesh since 1962 over about 90,000 ha shows that the direct cost of production works out to about Rs. 240 per tonne or Rs. 144 per metre^3. This is worked out after providing for two harvests, the first one from the main fellings and the second one from the coppice crop and compound interest rate of 12 per cent. The average stumpage yield of these plantations are 23 to 28 tonnes/ha, worked on a rotation of eight years. Yields of individual plantations have varied within wide limits. The estimated yields from felling coups of 1982-83 varied from 0.2 tonnes to 133 tonnes/ha. The market rates of Eucalyptus for April 1983 fixed by the Uttar Pradesh Forest Corporation in some depots were as given in Table 9.12.

In the high density, high-inputs eucalyptus plantations of V.J. Patel, the estimated cost per hectare over a three year period, as quoted by M.G. Gogate in an article in the *Indian Forester* is given in Table 9.13.

Obviously, the cost of plants, tubewell, etc. are not included.

USE IN INDUSTRY AND CRITICISM

Eucalyptus is a comparatively hardy species against grazing and browsing, is popular in most parts of the country as an avenue plantation and is also now being planted on a wide scale along the field boundaries. Several major industries, like The Star Paper Mills, Saharanpur and the Gwalior Rayon Plant at Harihar (Karnataka) are running on planted eucalyptus, while the Hindustan Paper Corporation Ltd 's newsprint plant in Kerala which has come into production in 1982 is also based on planted eucalyptus as one of its major raw materials.

Table 9.11: First year raising cost of eucalyptus

Item	Description of work	Rate in Rs./ha
1.	Survey and demarcation and clearing of site	21.25
2.	Ploughing	93.00
3.	Harrowing (two)	36.00
4.	Ridging	23.25
5.	Nursery costs:	
	(a) seed	6.00
	(b) preparation of nursery beds	134.00
	(c) polythene bags 21 cm × 8 cm × 150 gauge	92.00
	(d) pesticides	20.00
	(e) irrigation, weeding and other works	302.00
6.	Fencing:	
	(a) cost of barbed wire 3 strands	580.00
	(b) erection charges	46.20
7.	Weedings (three)	168.00
8.	Maintenance of roads and paths	25.00
9.	Labour huts	28.00
10.	Provision of drinking water and sign boards	12.50
11.	Hoeing (one)	30.00
12.	Firelines—maintenance	28.10
13.	Carriage of plants	15.00
14.	Plantation guard—one for every 200 ha from July to March	10.00
15.	Cost of tractor parts and their maintenance	315.00
16.	Miscellaneous and unforeseen	15.00
	Total	2,000.30 or say Rs. 2,000

Following the Vatava and other examples, eucalyptus plantation on agricultural lands by private parties as a commercial activity has been taken up on a large scale.

Table 9.12: Market rate of eucalyptus in 1983 fixed by U.P. Forest Corporation

Logs	1.8 metre long	60 to 90 cm diameter	Rs. 625/metre^3
		91 to 120 cm diameter	Rs. 700/metre^3
Poles	5 to 6 metre long	8 cm diameter	Rs. 17 to Rs. 20/pole
		13 cm diameter	Rs. 35-40/pole
Pulpwood	Without bark		Rs. 400/tonne
	With bark		Rs. 330/tonne
Firewood	With bark		Rs. 33/quintal

Table 9.13: Estimated cost and income of eucalyptus plantation per hectare

Number of tree	25,000
Spacing	60 cm × 60 cm
Rate of survival	80 per cent
Period of cutting	3 years
I. Initial cost of planting:	in Rs.
1. Preparation of land	250.00
2. Castorcake 50 gm/plant	900.00
3. N:P:K (12:32:16) 10 gm/plant	750.00
4. B.H.C. 10% 30 kg	60.00
5. Labour of Planting at 10 paise/plant	2,500.00
6. Irrigation: 20 per year @Rs. 75/ha irrigation	4,500.00
Labour	600.00
7. Fertilisers: Urea 6.5 tons	13,000.00
8. Soil working: 5 times/year @ Rs. 100/ha	1,500.00
9. Cutting @Rs. 0.50 per tree	10,000.00
Total cost in 3 years	34,060.00
II. Income and profits:	
Sale @ Rs. 10 per tree	2,00,000.00
Net profit/ha	1,65,940.00
Net profit/ha/year	55,313.00

There is some severe criticism of growing eucalyptus in India by some environmentalists. Sunder Lal Bahuguna calls it anti-social forestry. Claude Alvares calls eucalyptus hybrid as "an ecological terrorist that provides neither fodder nor fuel nor green mulch nor shade". True, the tree provides no fodder, but its unpalatability gives it a much needed protection, which enables it to grow in many hostile environments where other trees would not come up. True, it also provides little shade, but that makes it an ideal tree to grow on field 'bundhs' where its poor shade, combined with the fact that it does not attract birds means that its adverse effect on agricultural crops is minimal. The leaves do take longer than many other trees to provide mulch, and the tree also does not fix nitrogen in the soil, as some other trees like *sissoo* or *babul* do. But the tree does provide the biomass much needed in terms of fuelwood, pulpwood and timber. As V.J. Patel points out, especially for the high density energy plantations, the thinner parts of the tree, branches, etc., form about 30 per cent of the total outturn which provide much needed fuelwood. Patel goes on to say that the leaves left behind make "nice blanket" increasing the organic content of the soil; the thick crown cover, and the aggressive deep penetrating root system obstructing easy run-off of water and improving percolation deep into the ground, improves the water recharge. There is a feeling in some quarters that eucalyptus takes too much water and lowers the water table. All trees, shrubs and plants do require water for their growth. According to the investigations carried out by the Forest Research Institute, Dehra Dun, the water consumed by eucalyptus species per unit of biomass produced is less than several other tree species. Overall it may be stated that eucalyptus is as much an important part of the environment, and economic picture of land use in India today, as potato or tomato, both of which are also not indigenous to India, though the ecological factors concerning soil, water table, raising of nitrogen fixing leguminous fodder plants under light eucalyptus shade, etc., should continue to be closely studied in different regions where eucalyptus is raised, alongwith the vital economic necessity of growing more and more biomass without which environmental conditions are likely to worsen as people's needs of wood must be met.

Casuarina equisetifolia

Casuarina equisetifolia which originally comes from Bangladesh, Burma, Malaysia and North Australia has been cultivated on a large scale in many parts of India since 1916. The area under Casuarina could possibly be one lakh ha in India at present. It is fast growing, care-free species for sites and climates as varied as coastal sand dunes, hot humid tropics and even semi-arid regions. The species tends to be salt tolerant, is wind resistant and adaptable to moderately poor soils. Although not a legume, Casuarina has the ability to form root nodules and fix atmospheric nitrogen.

The wood of *Casuarina* burns with great heat and has been called by the U.S. National Academy of Sciences as the best fuelwood in the world. On good sites in Malaysia and the Philippines, the tree commonly grows 2-3 metres a year. In Malaysia and Philippines on good sites with spacing of 2 metre by 2 metre the yield is reported to be 7 to 20 ADT/ha/annum on a 7-10 year rotation. In India, the yield estimates are 4.5 to 10 ADT/ha/annum on a 5 to 15 year rotation. This species does not coppice.

Prosopis juliflora

Prosopis juliflora or mesquite is a hardy species especially for dry areas of rainfall 150 mm to 750 mm. This is a highly valued fuelwood. The species is native to Central America. The plant was brought to India by R.H. Beddome, then Conservator of Forests, Northern Circle, Madras in 1877, and now occupies a fairly extensive area in the country. Its roots penetrate to considerable depths in search of soil moisture. It is an aggressive invader and sometimes can be a nuisance. However, in India, it has been an unmixed blessing.

CVK Reddy records that at least one-tenth of the population of Andhra Pradesh, of the economically backward classes, gets off-season employment due to the aggressive presence of *Prosopis juliflora* around their habitations and wastelands. These people collect *Prosopis juliflora* fuel of all sizes, shave off thorns in their leisure time, take it to the nearest town in hired carts and make Rs. 10 to Rs. 15 in each trip. Reddy calculates the monetary benefits of *Prosopis juliflora* in Andhra Pradesh annually at Rs. 450 m. The proteinous parts are used as cattle feed, while the gum can be used as sizing material. The tree grows to timber sizes on sand dunes in Kurnool and Anantpur districts and the timber is strong and durable. The villagers use the timber for various agricultural implements. The tree coppices vigorously. The species has spread out extensively in many parts of India, e.g. Rajasthan, Gujarat, Maharashtra, Karnataka, Tamil Nadu, Delhi, Haryana and Uttar Pradesh.

Prosopis juliflora grows fast on a 15-year rotation. The expected yield is 5 to 7 ADT per ha/annum according to the US National Academy of Sciences. In India, the yields are reported to be 2.5 to 3.5 ADT/ha/annum in semi-arid areas, with rotation of 30 years and 5 ADT/ha/annum in areas with 500 mm rainfall at 10-year rotation.

Acacia nilotica or Babul

Babul is a moderate sized tree native to the Indian sub-continent, and is now cultivated throughout India and Pakistan, where its wood is a popular fuel, besides giving small timber. The calorific value of wood is about 4,900 kilo calories per kg, the specific gravity being 0.67. The tree is often grown on a rotation of 20 years in North India and 10 years in South India, and existing plantations in India today may be about 1,50,000 ha. Besides, *babul* is also spread extensively as scattered trees in the fields over many parts. The mean annual increment of *babul* varies from 1.4 to 5.8 ADT/ha/annum.

Poplars

As recorded by Chaturvedi (1982), the Uttar Pradesh Forest Department has carried out intensive agro-forestry farming with the help of a number of imported poplar species along with concerted programmes of research, irrigation, fertilisers and carefully controlled phytosanitary measures. Some of this work started in 1960, but greater concentration has been done during the last 15 years. Best success has been obtained in deep fertile soils and high water table areas in the Nainital Terai belts. The plantations are raised in carefully cleaned and tractor-ploughed areas at a spacing of 5 metre×5 metre. The varieties were imported from U.S.A., Italy and Australia. Among the more successful species raised are *Poplar deltoides* I.C., and poplar varieties G-3, G-48 and D-121.

Such plantations were raised over an area of about 1,335 ha between the years 1965 and 1981 in the East, Central and West Terai forest divisions of Uttar Pradesh. A plantation raised over an area of 20 ha in Gangapur Patia during 1966 was recently (1981) auctioned on standing basis. It was raised with polythene bag plants of Populus 1–488 during July to August 1966 rains. No irrigation in this had been done, unlike the later plantations and most of the trees were unhealthy and the stems sun-scorched. At the time of auction sale, the number of green trees available was 172/ha. Their analysis is as follows:

Diameter class in cms.							
5-10	*10-15*	*15-20*	*20-25*	*25-30*	*30-35*	*35-40*	*Total*
17	93	223	795	1,056	1,132	237	3,553

Total estimated volume 1,303.6 metre^3 (about 869 ADT)
Percentage of green surviving trees 36%
The internal rate of return of this plantation comes to 28%.

The rotation adopted is 10 years. However, with intensive farming, irrigation and manuring as in well-managed healthy stands, a shorter rotation of 6-8 years can be adopted. Trials for selection of proper clones will be a continuous process, and newer varieties with better growth and resistant to pests and diseases would have to be established. This is in common with experience with poplars in other countries. Poplar cultivation has been extended successfully in parts of Haryana and Punjab, with highly promising results. The timber is excellent for matchwoods, veneers, sports goods, and also gives some fuel-wood. Western India Match Company has carried out valuable extension work in poplar cultivation and the species is an ideal one for intensive agro-forestry practices.

Mixed plantations

At Gandhinagar, Gujarat, some block plantations of several species have been raised at a spacing of 1.5 metre × 1.5 metre under non-irrigated conditions. The measurements in these plantations have been taken by K. Gurumurti (1981). The total biomass achieved in these plantations over a period of 18-21 months is given in Table 9.14.

Table 9.14: Component-wise yield (ADT/ha) in energy plantations at Indroda, Gandhinagar

Component	*Eucalyptus terticornis* 21 months old May 1981	*Albizzia lebbeck* 18 months old	*Dalbergia sissoo* 18 months old	*Acacia nilotica* 18 months old	*Cassia siamea* 18 months old	*Acacia tortilis* 18 months old	*Prosopis juliflora* 18 months old
Wood	2.92	4.83	3.60	9.78	6.00	5.68	4.16
Bark	1.34	1.11	0.80	2.90	0.58	1.55	0.79
Branches	1.65	1.10	5.30	10.16	5.47	6.19	6.48
Total	5.91	7.04	9.70	22.84	12.05	13.42	11.43
Leaf	3.43	0.77	1.69	0.49	2.76	0.87	5.19
Root	4.26	4.88	3.48	6.69	3.78	3.44	3.07
Grand Total	13.60	12.69	14.87	30.03	18.59	17.73	19.69

The figures of oven-dry biomass for 36 months for these species have been reported as follows (Table 9.15) and are revealing.

Table 9.15: Oven-dry biomass output of different species

Sl. No.	Name of species	ODT/ha
1.	Eucalyptus hybrid	66.54
2.	*Albizzia lebbeck*	70.80
3.	*Dalbergia sissoo*	114.54
4.	*Acacia nilotica*	85.26
5.	*Cassio siamea*	86.10
6.	*Acacia tortillis*	87.41
7.	*Prosopis juliflora*	114.62

Sissoo and *Prosopis juliflora* give the highest yields, *babul* gives good yield, while eucalyptus yield is the lowest. Obviously, the rates of growth, specially for short rotations under different agro-climatic conditions need further close and detailed studies.

Wastelands in India

There are extensive wastelands in India suitable for energy and other tree plantations. Besides meeting the vital purpose of energy resources, such plantations will also greatly improve the environmental status of these lands. The extent of such lands in the various natural regions at present is about 80 m ha with broad break-up given in Table 9.16.

The above figure is besides 19 m ha of hot desert in Rajasthan, and about 10 m ha of cold desert in the Northern Himalayas, mainly in Ladakh, Lahaul and Spiti. Some of these wastelands are privately owned, some are owned by communities, but by far a good deal of these are government owned. The exact ownership of wastelands, where it is not already clear, needs to be worked out.

GOVERNMENT OR COMMON OWNERSHIP

Unlike agricultural lands, the problems of wastelands by far

Table 9.16: Wastelands in India

Type	Area, m ha
Ravine and gullied lands	4.0
Alkaline areas	2.5
Saline areas	4.5
Shifting cultivation	3.0
Riverine lands (*Khadar/Diara/Rao/Char/Bill*)	2.5
Coastal sands	6.0
Pastures and grazing lands	12.5
Fallows, mainly old, some current	15.0
Rain-fed non-paddy areas under agriculture	30.0
Forest wastelands	25.0
Total	105.0

is their common or Government ownership. Jeff Romm (1979) in his study, *The uncultivated half of India*, writes that "instead of being treated as a resource of vast developmental potential, the common lands are deteriorating. The poverty of population dependent upon them forces further depletion of productive capabilities". According to him poor conditions of the common lands and the forests affect the productivity of close to half the nation's land resources and if one includes both 'upstream' and 'downstream' effects, the welfare of more than half, the poorest half of its population. In the common lands and forests, public and private interests are competitive and neither has sufficient control of the resources to motivate investment. Everybody attempts to satisfy himself and none has sufficient control to hazard bets on the future. The crisis of Himalayan watershed, the disappearing forests of eastern India, the destruction of the western rangelands are examples of "tragedies of the commons", the result of unlimited claims, competitive interests and minimal security for investment by anyone. Some of such lands may be beyond management and as such are worth writing off. However, most of these lands can respond productively to investment".

EMPLOYMENT POTENTIAL

The question of utilisation of wastelands has also to be viewed in the light of our population problem, as discussed earlier. The age structure of our population is such that a large number of young people will need opportunities for gainful employment. As M.S. Swaminathan has pointed out, currently, we are a nation consisting predominantly of young persons. In other words, we should strive to avoid not only famines of food, but also famines of work. Unemployment continues to be a very serious problem and will probably get worse. Social forestry can provide a major means of employment to the rural poor.

Agro-forestry

As the FAO Study on Agro-forestry on India and Sri Lanka says, "A widely accepted definition of agro-forestry is 'a sustainable land management system which increases the yield of the land, combines the production of crops (including tree crops) and forest plants and/or animals simultaneously or sequentially on the same unit of land, and applies management practices that are compatible with the cultural practices of the local population'."

Although agro-forestry as generally understood, often used to be considered synonymous with agri-silviculture, the concept has been undergoing constant elaborations and refinement and may now be said to embrace the following components:

Agri-silvicultural systems;
Sylvipastoral systems;
Agri-sylvipastoral systems; and
Multipurpose forest tree production systems.

AGRO-FORESTRY IN INDIA

Agro-forestry commonly known as the *Taungya* system started in Burma in 1862 and came to India first in Bengal for raising sal in conjunction with agricultural crops in 1911. It was extended to Uttar Pradesh first for sal plantations in Gorakhpur in 1923 and was later extended to other divisions for sal and other species.

The system as now practised in India consists in leasing out the forest land to cultivators under an agreement by which the cultivators enjoy the land for a period of two to three years.

The use of land is allowed free of rent and in return the cultivators raise forest plantations of the desired species. Lately, in some areas the right to cultivate between the tree lines is auctioned and handsome returns are received by the Forest Department resulting in the regeneration of the forests, without any cost and at times receiving a premium in addition.

The range of crops raised by *taungyadars* is wide and includes cereal and root crops, a big range of pulses, oilseeds, vegetables, sugarcane, bananas and papayas. Generally less tall and dense crops which are required to be thoroughly weeded are preferred.

The Country Report for India presented at the Eighth World Forestry Congress, 1978 describes the position of agro-forestry in different States in India as practised during the last 50 years. In Andaman and Nicobar Islands, *Pterocarpus dalbergioides* has been successfully raised under *taungya* system along with agricultural crops of sugarcane and maize.

In Assam, sal has been successfully raised along with paddy and this has even reduced the *jhuming* there resulting in mutual advantage to forestry and agriculture. In the Kerala State, agro-forestry has come to stay. Foodcrops raised under *taungya* system are tapioca and paddy and to some extent gingelly and *ragi*. The tree species raised are teak, softwoods and eucalyptus. About 8,000 ha are cleared and planted every year in this way for regeneration of forests and combined production of foodcrops.

In Tamil Nadu, an area of nearly 2,000 ha is taken yearly for agro-forestry locally called *kumri*. Tree species being raised are teak, bamboos, eucalyptus species, sandal (*Santalum album*), tamarind (*Tamarindus indica*), *babul* (*Acacia nilotica*), wattle (*Acacia mollissima*), silk cotton, cashew and rubber. Food crops raised are *samai*, *varagin*, *ragi*, korea gram and tapioca. In Uttar Pradesh the agro-forestry system has been adopted on a fair scale. Average area taken under the system is about 10,000 to 12,000 ha per annum.

In West Bengal, agro-forestry is practised successfully for ensuring sal regeneration in the moist and damp forests in which natural regeneration has not been found possible otherwise. A good number of forest and agricultural species are used for the purpose. In Maharashtra, a new approach has been adopted to utilise the inter-space between the tree lines to grow economic crops like sunhemp, jute, mesta and oilseed bearing species like sun flower, castor, etc.

CASE STUDY OF AGRO-FORESTRY

A FAO Case Study on Rural Development through agro-forestry for non-resident cultivators in Bhinga, Bahraich district, Uttar Pradesh was made in 1981 which is extremely interesting. These forests, about 14,000 ha in area, situated about 40 kms from a railway station in a thickly populated and intensively cultivated tract in eastern Uttar Pradesh were reserved in 1879, and at that time were in a derelict and dying condition. There were old scattered trees of unknown age, but mostly hollow and overmature of sal, *haldu* (*Adina cordifolia*), *tendu* (*Diospyros tomentosa*), *mahua*, figs, *jamun*, standing over thickets of inedible thorny shrubs, chiefly *karaunda* (*Carissa opaca*) and *Jatropha gossipyfolia*; or, in areas on the outer edges where grazing was worst, over bare beaten ground.

Fifty years after the reservation, not much had happened except that the trees were more hollow and more scattered, and the number of cattle had increased. In 1935, a Working Plan made two schemes of Agro-forestry initiating intensive management of these potentially valuable forests. Twelve Agro-forestry Centres were set up with nearly 800 tenants. Two years' free cultivation was allowed, after the area had been clearfelled and tree species were raised by the tenants in the third monsoon.

As the study describes, after the sowing of the tree species, either one to two or two to three more *Kharif* and *Rabi* crops were harvested depending upon whether fast growing (teak, *sissoo*) or slow growing species (sal, *jamun*, *mahua*) were sown. In the timber working circle, the principal species were sal, *jamun*, *mahua* and to a limited extent, *sissoo* and teak and the lines 3.7-4.6 metres apart. In the other working circle, fodder species were introduced mainly for lopping, principally *Terminalias*, *Albizia*, *Bauhinia*, *neem*, mulberry, while species mainly for timber were *sissoo*, sal, *semal*, mango, etc., with *jamun* as an under-storey for fruit and small timber in lines 7.6-9 metres apart to enable fodder and thatching grasses to develop between the lines. A timber line alternated with a fodder line, with *jamun* to be coppiced on a short rotation under the light demanders to provide small timber for the villagers.

The scheme was successfully worked for the amelioration and betterment of the population of the surrounding 86 villages. The supply of small timber and fuelwood from thinnings of the young plantations increased enormously. The plantations also provided green-leaf fodder from loppings and production of crop residue fodder of *Kharif* and *Rabi* crops. The clear felling of forests before planting also made large quantities of fuel available far in excess of the villagers' requirements resulting in the starting of brick kilns on some of the alkali lands outside the forest. Fodder and thatching grasses appeared in the agro-forestry plantations as soon as cultivation was stopped and continued for a number of years under the tree crops, unimpaired by the thorny shrubs which the agro-forestry operations had eradicated. Operations also generated an enormous increase in employment in villages. As many as 3,000 sawyers were employed, while the labour on felling and carting trebled. Apart from the 8,000 households who benefitted by free concessions, a further 15,000 or more found employment and wages. It is worth pointing out that some of the forests giving the highest production per hectare per annum in Uttar Pradesh at present have been regenerated by agro-forestry practices.

SUKHOMAJRI CONCEPT

A crucial problem of growing agricultural and forestry crops together is of water and protection. Here, the Sukhomajri concept is of great value. Sukhomajri is a small village near Chandigarh in Ambala district, Haryana. Originating in an effort to reduce heavy siltation of Sukhna lake at Chandigarh, the Sukhomajri has developed as a major concept in water and soil conservation and afforestation. The idea has been extended to the nearby Nadah village. Executed by a devoted band of research workers of the Central Soil and Water Conservation Research & Training Institute and the Ford Foundation, almost a perfect model has been developed.

At these places, water has been stored in small dams on hillsides, and used by gravity through a conveyance system to irrigate the fields below. With the help of water thus collected, forest nurseries have also been raised and trees planted on wastelands. The life of these small dams depends very much on protection of their small catchments. A strong urge has thus been created in the villages to rigorously protect the trees and the *bhabhar* grass planted in catchments which would otherwise be almost impossible. *Bhabhar* grass is being used for making ropes on small machines in the villages. Water has been distributed equally to all the village residents irrespective of the fact that they may or may not own land. The persons not owning any land are free and do sell their water to the persons who have land, etc. Water Users' Societies have been constituted. Results in increase of agricultural produce have been spectacular.

The problem of protection in agro-forestry is extremely grave and many of the trees planted do not survive because the trees cannot be adequately protected. The idea of 'social fencing' has been developed at Sukhomajri. It is most important that the beneficiaries are organised to protect the trees which they can do cheaply if they willingly decide to do so together. For this purpose various Forest Users Organisations/Associations should be constituted in agro-forestry areas.

HEADLOADERS OF FUELWOOD

Mention deserves to be made of the problem of headloaders of fuelwood specially women, prevalent in many parts of India, e.g. Chhota Nagpur tract of Bihar, Bankura and Midnapore districts of West Bengal, Mirzapur district of Uttar Pradesh and many districts of Madhya Pradesh and other States. The practice is largely adopted by tribals and other people with little or no land. The problem was typically studied by Bhaduri and V. Sarin under the guidance of N.G. Basu, then of the Xavier Institute of Social Services, Ranchi. Detailed investigations conducted of 170 headloader households of nine villages in Ranchi district showed that headloading has become a major occupation of women folk in these areas. In some of these villages almost 48 per cent of the households were engaged in headloading, but in majority of these villages, more than 20 per cent of the households were having headloading as their major occupation. The households either have little land, or have uplands and wastelands mostly, where agriculture is hardly remunerative. Most of the people belong to scheduled tribes and backward communities. The people collect fuelwood from the forests, carry them long distances of 6 to 8 or 10 miles or more, partly by train and partly on foot and sell it in the nearest towns for a livelihood. Female headloaders are mostly in the age group between 25 and 40 while majority of male headloaders are either below the age of 15 or above 40. Women at the best carry two bundles of wood of 10 kg each and carry both the bundles on their head. One male woodseller can carry four such bundles in *bhar*, two on each side on shoulder. The price that each headload (20 kg approximately) can fetch (1981) varies between Rs. 5.50 and Rs. 6.50. The headloaders generally move in a group whether in the forest to collect fuelwood or in the market to sell these. They often spend the night at the railway station or some other public places and are exploited in matters of small illicit payments by the petty forest staff, railway running staff and the police. In certain villages *kautilya* tax system is in vogue. Each headloader household has to pay some money to a village headman, who deposits this in proper place, to assure carefree collection of fuelwood from forests. The whole process runs smoothly due to some invisible links and gentleman's agreement between those who are involved.

The women headloaders stay out almost the whole day. The practice has specially grown during the last 15 to 20 years. This practice is extremely hard to the people besides being very harmful to the forests. Some people however do this as a supplementary or slightly better source of income, in conjunction with truck owners and would not accept daily labour work, if offered. It is proper that such people are employed in social or agro-forestry programmes in revenue or forest lands on an organised basis, and the practice of taking fuelwood on headloads stopped, in the mutual interest of these people, the forests and in the interest of the environment of the locality.

Energy-saving devices

A method of augmenting the fuelwood supply is by the use of improved forms of wood burning appliances like *Angheetis* and *chulhas*. As pointed out by the Report of the Planning Commission Fuelwood Study (1982), the traditional ways of burning wood for cooking and heating are in general very inefficient, and their energy requirements for cooking is often five times as high as cooking on a kerosene stove, as about 90 per cent of the heat value of wood is wasted. Improvement in the stove designs has been found to reduce the consumption of fuelwood for cooking up to about 70 per cent. In this connection reference is invited to the Nadah (Haryana) and Palampur (Himachal Pradesh) and other types of improved *chulhas* developed in various parts of the country which deserve to be widely adopted all over. Improved crematoria also save as high as 40 per cent of fuel needs. By appropriate R & D efforts and suitable adoption of such improved devices, considerable saving of fuelwood can be achieved.

Programmes of social forestry

A good number of programmes have emerged and are emerging for social forestry with the help of the World Bank and foreign aid. A summary of these programmes together with anticipated physical targets for 1982-87 is given in Table 9.17.

A major umbrella social forestry project is being worked out to cover all or most States for extensive and intensive tree plantation drive in private lands and government degraded forests.

SUGGESTIONS

The Report of the Fuelwood Study Committee of the Planning Commission (1982) has made very valuable suggestions for a major thrust in social/agro-forestry programmes to be urgently undertaken. On the basis of the growth rate assumed for the economy and the present strategy of growth being continued without any change, energy requirements would reach levels which cannot be met through current programmes and policies. Therefore, augmenting fuelwood supplies is of prime importance and various additional measures shall have to be initiated and implemented effectively. Some of the main recommendations of the above Committee are as follows:

1) *Policy*

a) Recognition of fuelwood as one of the basic needs of the people and incorporating it in the Minimum Needs Programmes.

b) Restricting uncontrolled grazing in the forests and encouraging stall feeding together with enunciating an integrated policy of land and livestock reforms.

Table 9.17: Social forestry projects in India anticipated physical targets (1982-87), ha

State	Agency	Total cost (Rs. mill.)	Village wood-lots	Farm forestry	Institutional lands	Community self help	Canal	Roadsides Railway	Rail-way	Degraded forests	Total
U.P.	World Bank	400	5,000	4,000	--	3,080	16,000	7,000	4,000	13.600	52,680
Gujarat	World Bank	654	37,400	76,000	—	—	2,000	31,600	3,400	30,000	1,80,400
W.B.	World Bank	349	6,000	52,000	—	—	—	20,000	—	15,000	93,000
Haryana	World Bank	316	12,000	21,780	1,000	—	4,850	3,200	800	15,500	59,130
J & K	World Bank	237	15,500	3,000	1,270	—	—	–	—	17,000	3,770
Karnataka	World Bank	592	8.000@	10,000	—	—	2,000	18,000	—	60,000	1,88,000
Tamil Nadu	Sida	450	1,32,000@	39,200	—	5,250 (fodder)		——6,075 km -——		—	1,62,300
Bihar	Sida	400	—	20,000	—	3,500 (tasser)	—	–	—	72,000	95,500
Orissa	Sida	230	25,000	1,387	—	—	—	—	—	35,000	61,387
Maharashtra	USAID	564	5,250	2,750	—	—		——28,195— -—		37,000	73,195
M.P.	USAID	470	48,000	—	—	—		——15,450———		—	63,450
A.P.	CIDA	400	47,000@	1,02,000	—	—	—	—	—	42,000	1,91,000
Total		5,062	3,41,150	4,07,967	2,270	11,830	24,850	1,23,445	8,200	3,37,180	12,56,812 +6,075 km

@Tank foreshore

Notes: Village woodlots are on community lands. Farm Forestry is on private lands.

2) *Survey*

Estimation of present availability of fuels, identification of available forest area and wastelands, coastal lands, desert fringes, *usar* lands, *Bhoodan* lands, etc.

3) *Improved management programmes*

a) Stepping up the annual fuelwood plantation programmes up to about 1.5 m ha per year during the next 10 years to meet the projected fuelwood needs.

b) Developing fuelwood farming as a major agro-forestry farming system.

c) Associating the corporate sector through the provision of waste/forest lands on long-term basis.

d) Raising densified fuelwood plantations of fast growing coppicing species.

e) Initiating a time bound ten-year programme for covering each village with a minimum of 4 ha of fuelwood plantation on Government or community land with people's participation at Government cost.

f) Covering of available roadsides, canal banks and rail sides with fuelwood plantations.

g) Utilisation of all marginal farm lands, unsuitable for agriculture for raising perennial tree crops in rotation with annual field crops.

h) Establishment of *Van Vigyan Kendras* on lines of *Krishi Vigyan Kendras* to educate the rural population on modern forestry.

4) *Complementary programmes*

a) Providing adequate incentives for introduction of fuelwood saving devices including the utilisation of sawmill and logging waste for briquetting.

b) Linking fuelwood plantation programmes with wood gasification plants on pilot scale in the first instance.

c) Extending credit facilities for encouraging fuelwood plantations through hypothecation of land and tree crops.

d) Propagation of community biogas plants in the villages to save fuelwood.

5) *Technological development*

a) Identification of current gaps in technology and development.

b) Identification and breeding of suitable fast growing, coppicing (or otherwise easily regenerating) tree species of high calorific value for different agro-climatic zones.

c) Establishment of germplasm banks and intensification of research on hybridisation/tissue culture, etc., for developing fast growing tree species.

6) *R & D efforts*

a) Establishing a strongly motivated extension wing at the Centre and in the Forest Departments in each State.

b) Initiating a strong and time-bound research and development work through various recognised institutes and industries on pilot plant basis in respect of direct use of fuelwood, and chemical or bio-chemical conservation of wood.

7) *Integrated action plan*

It is essential to have an Integrated Action Plan of tree plantations in various Districts and States all over the country. Massive programme of fuelwood farming would require adequate financial support which is estimated to be of the order of Rs. 800 to Rs. 1000 crores per annum. Besides Government funds, the programme will therefore have to be supported through joint ventures and should attract institutional finance through appropriate bankable projects, preferably with shared benefits to the local people.

CHAPTER 10

Wildlife and Biosphere Reserves

Introduction

Wildlife is an integral part of forests and environment in India, as elsewhere in the world. Despite serious destruction and many problems, India still has a rich and varied wildlife, say compared to Europe. The Expert Committee of the Indian Board for Wildlife in their Report (1970) defined wildlife to mean "the entire natural uncultivated flora and fauna of the country". The Wildlife (Protection) Act, 1972 defines wildlife to include "any animal, bees, butterflies, crustacea, fish and moths and aquatic or land vegetation which forms part of any habitat".

As the Director of the Indian Wildlife Institute V.B. Saharia (1981) points out, the ethics of wildlife has evolved the world-over as the idea of a community of interdependent parts. Man's instincts prompt him to compete for his place in that community, but ethics prompts him also to co-operate, in order that there may be a place to compete for. The land ethics simply enlarges the boundaries of the community to include soils, waters, plant and animals.

A poem in the *Yajur Veda* invokes universal peace with special mention of the "peace of air, peace of earth, peace of waters, peace of plants, peace of trees." This reference to Vedic poetry reveals how responsive the Indian sensibility was, to the benediction of nature and wildlife. The founding fathers of our Constitution also realised the need for such an ethics. In the Section on Directive Principles of State Policy, the following duties for the State and the Citizens were laid down:

Article 48 states that "the State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country."

Article 51-A *inter alia* states that "it shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures."

India's wildlife

India has about 350 species of mammals, 1,200 species of birds in nearly 2,100 forms and more than 20,000 species of insects. There are eight species of deer, more varieties of cats than in any other country, several forms of wild goats, the Asiatic lion, the one-horned rhinoceros, and the Indian elephant, etc. India has a large number of representatives of both the Asian and the European species. There is a wide range of habitat in the country supporting an equally wide range of fauna. However, wildlife has gradually diminished in numbers, in many parts in the forest areas. The population of important species of wildlife is critical except in National Parks, sanctuaries and closed areas.

The Himalayan foothills

The forests of the Himalayan foothills are one of the richest areas for the typical big mammals of north India. The elephant, the *sambar*, the swamp deer, *cheetal*, hog deer, barking deer, and wild goat are all found, abundantly in this area. The tiger, panther and wild dogs are the co-predators, while the hyena and the jackal are the camp followers of the tiger and the scavengers of the tiger kill. Both the black and the sloth bears are found in this area. The porcupine is an important rodent. The great Indian one-horned rhinoceros which once ranged along the Himalayan foothills is now found in Assam and North Bengal only. The brown antlered deer, also called the dancing deer of Manipur by the late E.P. Gee is another rare deer found in this region confined to Keibul Lamjo Sanctuary in Manipur. Perhaps this is the most threatened deer in the world. The Tarai belt has large elephant herds though many of their habitats have been fragmented by agriculture, construction of reservoirs for hydro-electric generation and other human artifacts. The tiger has become rare with the disappearance of a large part of its habitat and with it its prey base of large ungulates. In some places as Kheri Lakhimpur district of Uttar Pradesh it is directly in conflict with man, posing problems of man eating and cattle lifting. It is, however, at present fully protected by a total ban on its killing. This area also supports the Gangetic *gharial.* The hispid hare and the pigmy hog till recently thought to be extinct have been re-discovered in the Manas Sanctuary in Assam in 1971. In the 1950s, E.P. Gee established the existence of a new species of monkeys, the golden *langur* which is now named after him as *Presbytis geei.*

The high altitude region of western Himalayas

One of the typical animals of the old desert of Ladakh and Tibet is the wild ass. There are good number of species of wild-goats and sheep. The largest bovid, the *yak* has been domesticated for centuries by the people of Tibet and Ladakh, but wild *yaks* are still found. They are black with long black horns and a little white on the muzzle.

There species of wild goats occur, the *tahr* in the highest coniferous forests is a gregarious animal grazing in herds, while sentinels look out for possible danger. Even higher on the rocky slopes lives the *markhor*, the finest of all goats with its long horns shaped like thick, heavy, cork screws. The third goat is the *ibex* having a much wider range extending all over Central Asia and extending westwards as far as Spain.

Among the sheep there are three species, *nayan* being the largest extending from Ladakh to Tibet, also called the Marco-polo's sheep. Then, there is the *bharal* or blue sheep occurring in western Himalayas and extending to Sikkim and Nepal. The *shapu* or *urival* is the smallest of the wild sheep and inhabits grassy slopes below the tree line. There are two kinds of antilopes, the *chiru* and the Tibetan *gazelle.* Two deer are prominent in the higher western Himalayas. The *hangul* or Kashmir stag is the local representative of the European red deer, mainly confined to the Dachigam Sanctuary in Jammu and Kashmir. The musk deer is an important deer which inhabits high altitudes bordering the tree line. It is much valued for its musk pods, collected from the males and used in the manufacture of perfumes, etc. Large-scale poaching has made this deer a highly threatened species, and a special project called the Musk Deer Breeding Project has been recently launched by the Government of Uttar Pradesh to protect it. A number of small mammals live above the tree line. Among mammals is found the snow leopard, one of the most beautiful animals with a long thick coat of smoky grey with black rosettes. The other predators are the wolf, the fox, small cats and the black and brown bears. Among the birds of the region are a number of pheasants, the most important being the Himalayan monal pheasant, the western tragopan, the satyr tragopan, the koklas, the white crested khalij and the cheer pheasant. These birds have very attractive plumage, and are hunted for their meat as well as feathers, and as a group are rare and threatened.

The eastern Himalayan sub-region

In this region there are some of the Indo-Chinese fauna. The red *panda*, hog badgers, ferret badgers, and crestless porcupines are typical species. Three kinds of goat antelopes, viz. serow, goral and takins are found here.

Peninsular Indian sub-region

Peninsular India is the true home of the Indian fauna. This consists mainly of two broad zones, first, the tropical deciduous woodlands and the desert region of Rajasthan or the Thar. The larger inhabitants of the Indian deciduous forests include elephants, *muntjak*, the sambar deer, the wild boar and the *gaur*. There are a number of species of deer and antelopes, the most attractive of these being the *cheetal* or the axis deer. Usually found in herds of five to ten, it occurs in groups of several hundreds congregating in the open areas of the Kanha National Park. A small relative of the axis deer is the hog deer, but it prefers rather swampier meadows. Besides, the swamp deer, or the *barasingha* is a large deer and has stags having fine antlers containing up to 12 points. The hard ground *barasingha*, found only in the Kanha National Park is a separate race. The barking deer or the kakar, and the four-horned antelope having two pairs of small horns also occurs.

The three main predators of the region are the tiger, the leopard and the wild dog or dhole. The dhole also characterises the rain-forest environment. It is an animal which hunts in packs. Of course, the most famous animal of peninsular India is the tiger which is also India's 'National Animal'. The tiger perhaps had its origin in the Palaearctic region. The Indian tiger or the Royal Bengal Tiger, as it is commonly called has come to be recognised as the type species (*Panthera tigris tigris*) among the eight races of the tiger that are recognised in all its ranges. The beauty of the tiger, its grace, its strength and courage have made tiger-hunting a rare sport over the ages. The tiger population which was estimated to have been around 40,000 in India at the turn of the century was reduced to less than 2,000 in the early 1970s.

The other two big cats of the peninsular India are the cheetah and the lion, which also had their origin outside India in the Ethiopian region. The cheetah or the hunting leopard which is the fastest moving land animal in the world is now unfortunately extinct in India. The Asiatic lion like its African cousin is an animal of the open grasslands. It is slightly heavier in build than its African relatives. They live in family groups called 'prides'. Hunting is mainly done by the females. The lion once had a wide range of distribution in western and central India across into Persia, Arabia and the Middle East. It has now disappeared from all its previous range, and is confined to a small pocket of forests in the Gir National Park of Gujarat. The other carnivores in this region are the striped hyena and the jackal. The elephant is missing from the central Indian plateau, particularly in the States of Madhya Pradesh, Andhra Pradesh and Maharashtra, but again appears in Karnataka, Kerala and Tamil Nadu and extends into Sri Lanka. In South Karnataka, the elephant is specially associated with the famous *Kheda* or elephant catching operations. A good adult of the biggest bovid of the Indian origin, namely the *gaur*, also called the Indian bison may weigh a tonne and stand over 6 ft at the shoulder. *Gaur* is also a rare and protected species. It has also been subjected to periodic mortality due to rinderpest.

The Indian desert

Rodents are the largest group in the mammal fauna of the Indian desert. The Indian desert gerbils are burrow dwellers and can live on perfectly dry food with no water at all, all their body fluid being derived from metabolic water. The largest mammal of the Indian desert is the Asiatic wild ass, which lives in the south-west of the Thar desert on the Little Rann of Kutch. These animals have special tolerance to dehydration. Blackbuck found in this region, is sometimes protected by villagers through religious beliefs. One such tribe, the Vishnois of Rajasthan afford full protection to blackbuck and would not even hesitate to kill any person daring to hunt this animal. Desert cat and the caracal are also found here. Snakes, lizards and tortoises are well represented in the desert. Among the birds of the desert, special mention needs to be made of the Great Indian Bustard which is a large beautiful bird inhabiting dry open country. Unfortunately this bird has become seriously endangered.

The tropical rain forest region

This region provides the main shelter to wild elephants, *gaur* and other animals. Among the deer, there is only the barking deer. Most of the species in this region are tree-dwellers, the important among them being the non-human primates. In the north-eastern region of Arunachal Pradesh and Assam, there is the hoolock gibbon, which is the only ape found in India at present, besides the golden langur, the capped langur or leaf monkey, the Assam macaque and the pig-tailed macaque. In the South, there is the lion-tailed macaque, the Nilgiri langur and the slender loris. Bats are widespread among flying mammals. Among the flying squirrels there is the Nilgiri mongoose, the stripe-necked mongoose, the Malabar civet and the spiny mouse. The tropical rain forests are also the storehouse of a large variety of plants and animals, representing one of the richest gene pool resources of flora and fauna in the country.

The Andaman and Nicobar islands have about 35 species, of mammals, a number of interesting reptiles and a variety of marine fauna. The Andaman pig is one of the large mammals. We also have the crab-eating macaque, the palm civet and the various species of deer which were introduced there during the 1920s and include the spotted deer, the barking deer, the hog deer and the sambar. Among the important marine mammal species are the dugong, the false killer whale and the dolphin.

The avifauna recently studied by Humayan Abdulali is quite rich. A number of marine turtles are indigenous to the island.

Destruction of wildlife

Although love and regard for wildlife is a part of India's ancient culture, yet there has been serious destruction of wildlife specially during the last 40-50 years. As many as 66 species of mammals, 38 species of birds and 18 species of amphibians and reptiles including all the three species of crocodilians found in India are now listed in Schedule 1 (as amended) of the Wildlife (Protection) Act 1972 as rare and threatened. The important causes of this destruction are in the first place, the heavily increasing pressure of population, expansion of agriculture, and reclamation, destruction and opening up of forest lands by extensive new roads. The tribal system of organised hunting in large groups on special festival days has also been particularly responsible for wildlife destruction in certain areas. The third important reason for destruction of wildlife is the use of fast running vehicles and that of poaching for commercial purposes including meat, ivory, rhino-horns and skins. The destruction of wildlife has indeed been phenomenal despite the protection measures employed. The Forest Service remains in-charge of protection of wildlife in the country.

Indian Board of Wildlife

The Indian Board of Wildlife (IBWL) was set up by the Government of India in 1952 for the following purposes:

1) To devise ways and means for the conservation and control of wildlife through co-ordinated legislative and practical measures with particular reference to seasonal and regional closures, declaration of certain species as protected, and prevention of indiscriminate killings.

2) To sponsor the setting up of sanctuaries, national parks and zoological gardens.

3) To promote public interest in wildlife and the need for its preservation, in harmony with natural and human environments.

4) To advise Government on policy in respect of the export of living animals, trophies, skins, fur, feathers and other wildlife products.

5) To perform such other functions as are germane to the purpose for which the Board has been constituted.

6) To prevent cruelty to birds and animals caught alive, with or without injury.

The Board has also constituted four wings for looking into the problems of management of (a) zoos, (b) birds, (c) fisheries, and (d) flora. The Executive Committee of the IBWL meets once a quarter to review the action taken on its recommendations. An Expert Committee of the IBWL made a comprehensive study of conservation problems in 1970. Another Expert Committee was set up by the IBWL to examine the zoo management and submitted its report in 1975.

Kaziranga National Park

The story of the Kaziranga National Park may be taken as a typical example of the destruction of wildlife and what has been done in one case for taking steps for the protection of the one-horned rhino. For the Great Indian Rhinoceros (*R. unicornis*), it was recorded at the turn of the century that barely a dozen rhinos existed in the then Kaziranga area. During those days the forests were thick and communication was difficult. Hence, this estimate could be wrong, but it was evident that numbers were not plentiful during the time. The Kaziranga area was declared a reserved forest in 1908. Another tract of forest, now known as the Manas Wildlife Sanctuary was also constituted into reserved forest for the protection of the flora and the fauna. Both these reserved forests were subsequently called game reserves, and the later part of the 1940s the name 'game reserve' was changed into 'wildlife sanctuary'. Poaching for rhino horn was common because of the high value fetched by it. It was in those days worth half its weight in gold. Sometime in 1935, the Government of Assam had to send a Company of Army Rifles to Manas to control poaching of rhinos. Similarly Kaziranga was also subjected to serious poaching. Sometime in the mid 1930s when Kaziranga was inspected by a Forest Officer, he found 40 carcasses of the rhino with the horns removed, as recorded by E.P. Gee. A few years later the Assam Legislative Council passed the legislation, declaring the rhino horn a forest produce, wherever it is found so that anybody found with the rhino horn without any authority could be prosecuted in a court of law. In 1938, Kaziranga was opened to visitors.

Under gradual protective measures taken by the Assam Forest Department, the rhino population began to recoup. The rhino population in Kaziranga during the 17 year period (1961 to 1978) has been estimated to increase from 384 to 960.

National parks and sanctuaries

The number of National Parks and Sanctuaries has been gradually increased during the last 40 years. Table 10.1 shows the State-wise number of national parks, wildlife sanctuaries and zoos in India as on 31st Dec., 1979, along with the areas occupied by each national park and wildlife sanctuary.

It would be seen that a total area of 7.5 m ha of forests is occupied by wildlife sanctuaries, and a further 0.7 m ha of forests is occupied under National Parks making a total of 8.3 m ha under the National Parks and Wildlife Sanctuaries which is about 11 per cent of the 75 m ha of the existing forests.

The Project Tiger

A number of special projects have been taken up in recent years for the protection of wildlife. Among the foremost of these is the 'Project Tiger'.

It may be recalled that in 1950s and 1960s mistakenly tiger shooting was accepted in India as a method of encouraging tourism, and earning foreign exchange. This led to a grim situation. The Expert Committee appointed by the Indian Board for Wildlife on Wildlife Conservation in India (1970) with K.S. Dharakumarsinhji as President, and K.S. Sankhla, who had carried out a special study on the Indian Tiger as a Nehru Memorial Fellow as its Member-Secretary and with several other eminent members recorded as follows on the subject:

"In view of the fact that the ban has become almost a political issue between vested interests (mainly shikar companies) some of whom appear to be reconciled to shooting the last tiger provided they get a cut out of it, and others, the Centre and the States will have to work in close partnership to see that India's most admired animal is not lost for ever."

As a result, the Executive Committee of the Indian Board

Table 10.1: Area under national parks and wildlife sanctuaries in India as on 31st Dec., 1979 (sq kms)

State/Union Territories	Zoological Gardens	National Parks		Wildlife Sanctuaries	
	(Nos.)	(Nos.)	(Area)	(Nos.)	(Area)
Andhra Pradesh	2	—	—	14	8,819
Assam	1	1	430	6	805
Bihar	—	—	—	14	3,883
Gujarat	6	2	1,429	4	5,432
Haryana	2	—	—	1	1
Himachal Pradesh	2	—	—	26[a]	2,088
Jammu & Kashmir	—	—	1,550	4[b]	178
Karnataka	1	3	1,550	15	4,478
Kerala	2	1	97	6	2,229
Madhya Pradesh	3	3	1,201	22	15,352
Maharashtra	5	4	570	10	11,088
Manipur	—	1	25	—	—
Meghalaya	—	—	—	1	5
Nagaland	1	—	—	2	211
Orissa	1	—	—	18[c]	3,141
Punjab	1	—	—	4	249
Rajasthan	6	—	—	13[d]	5,755
Sikkim	—	1	850	—	—
Tamil Nadu	3	1	3	7	2,088
Uttar Pradesh	4	2	1,025	12	4,750
West Bengal	4	—	—	11	709
Total States	44	19	7,185	190	71,183
A & N Islands	1	—	—	4	20
Arunachal Pradesh	—	—	—	4	3,001
Chandigarh	—	—	—	1	25
Delhi	2	—	—	—	—
Goa, Daman & Diu	—	—	—	3	353
Mizoram	—	—	—	1	466
Total Union Territories	3	—	—	13	3,865
All India	47	19	7,186	203	75,048

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[a] Areas under Gamgutsiya-Behli Sanctuary (Champa District).

[b] Chumnai Basin Wildlife Sanctuary (Anantnag Distt.).

[c] Hadagarh Sanctuary (Keonjhar Distt.).

[d] Jawaharnagar Sanctuary (Kota Distt.) not available.

for Wildlife recommended a total ban on the killing of tigers for a period of five years from July, 1970.

Following the recommendations of a Task Force of the Indian Board for Wildlife, the Project Tiger was initiated in 1973 with nine tiger reserves to which two more reserves were added later, extending in 10 States with a total area of 1.58 m ha. As described by the Director of the Project (1981), H.S. Panwar, the management strategy has been to identify the limiting factors of the habitat, and to seek to mitigate these by special management measures. Briefly, the strategy implies arresting of regressive trends by such operations as intensive anti-poaching, fire-protection, elimination of cattle grazing, eradication of weeds, soil conservation measures, relocation of human habitation, judicious water development and the like. Systematic management plans conforming to this approach have been prepared for each reserve, and annual plans of operation are prepared and followed each year. The guiding principles of management of these plans are the following.

1) Conforming to the concept of biosphere preservation, to seek to eliminate all forms of human exploitation and disturbance from the core zones, and progressively minimise these in the buffer areas.

2) To limit the management to the repairs of the damage done by man and to seek to restore the ecosystem as close to its natural functioning as possible.

3) To build up the habitat by mitigating limiting factors arising out of abuse and over-use, and thus to build up the wildlife populations to the intrinsic carrying capacity of the habitat, scrupulously avoiding management assistance capable of pushing the growth of populations beyond this stage.

4) To avoid all anthropomorphic considerations, to consider facts about the habitat and wild animals, and carefully monitor the ongoing changes in flora and fauna.

Each tiger reserve has a core zone besides the buffer zone. The total area and the core area of each tiger reserve along with the name of the State in which the reserve occurs and the type of forest is given in Table 10.2.

A sum of about Rs. 9 crores was spent under the project up to 1979-80. The scheme has been specially assisted by the World Wildlife Fund against a promised assistance of US

Table 10.2: Tiger reserve forests in India

S. No.	Tiger Reserves and forest types	Total area (in sq km)	Core area (in sq km)
1.	Melghat (Maharashtra), deciduous forest dominated with teak and bamboo	1,571	311
2.	Palamau (Bihar), eastern peninsular forest with an interesting association of sal and bamboo	930	200
3.	Simlipal (Orissa), moist miscellaneous forest of the east (Champ and Sal)	2,750	300
4.	Kanha (Madhya Pradesh), central highlands of the peninsular India (Sal and miscellaneous forest)	1,945	940
5.	Bandipur (Karnataka), miscellaneous forest of the Western Ghats	690	335
6.	Corbett Park (Uttar Pradesh), central foothills of the Himalayas with sal as the predominant species	520	320
7.	Manas (Assam), eastern foothills of heavy rainfall with *terai* riverain, reeds and swamps, semi-evergreen to ever-green forest	2,840	391
8.	Ranthambhor (Rajasthan), dry deciduous open forest of the Aravalis and Vindhyas in the West	392	167
9.	Sunderbans (West Bengal), tropical estuarine mangrove forest and other littoral vegetation	2,585	1,330
10.	Periyar (Kerala), moist deciduous, tropical wet-evergreen and semi-evergreen forest	777	350
11.	Sariska (Rajasthan), dry deciduous forest	800	498
	Total	15,800 (or 15,80,000 ha)	5,142

$1 million. A sum of $5.2 lakhs was provided up to 1980 in the form of equipment, foreign expertise and training in specialised fields and literature. The States have given up a revenue of Rs. 20 crores per annum for these reserves as a part of the strategy. The execution of the project is done by the State Governments in their respective areas in each reserve with a team of technical and field personnel. But the Inspector General of Forests and Director, Project Tiger at the Centre oversee the Scheme. The reserves have been provided with jeeps, motorcycles, jet boats and camels as per their varied requirements. A well-knit communication system has been installed, comprising of wireless sets and telephones, relating to anti-poaching, fire protection and animal monitoring. Good success has been achieved in ensuring effective fire protection in the reserves. As many as 33 villages have been specially relocated outside the reserves after special persuasive efforts—22 from the Kanha Reserve, seven from the Ranthambhor Reserve and two from the Corbett Reserve. Special steps have been taken for water development. Grazing has been completely stopped in the core area of all the reserves, and is restrictedly permitted in the buffer zones. All cattle camps that existed inside the reserves have also been moved out. Habitat improvement works have been undertaken. All tree fellings have been completely stopped in all core areas. The activities are specially controlled by a Steering Committee of the Tiger Project of the Indian Board of Wildlife. A major success in the operation has been achieved. The population of the tigers in the nine regional tiger reserves estimated at 268 in 1972 nearly doubled by 1982. There is a major improvement in the overall habitat conditions and in the State of wildlife miscellany. A number of reserves report a spill-over of the increase to the adjacent forests outside the reserves.

Prince Philip, the Duke of Edinburgh visited Siriska Tiger Reserve in March, 1982 and besides seeing the progress there apprised himself with the overall progress of the Project Tiger. In his letter following this visit, he wrote to the Prime Minister of India:

"There is no doubt that Operation Tiger is a great success and I hope that the realisation that conservation measures can be so effective in such a short time will encourage all those responsible for various aspects of the conservation of nature in

India to redouble their efforts to create and implement a long-term plan for India".

According to a world famous conservationist, Operation Tiger has indeed been justly described as one of the great conservation successes of modern times.

The *Le Monde* a prime French daily, carried the following lines:

"Driving along the approach to Kanha (a Tiger Reserve), the long stretch of forests looks desolate and desert-like. But once in the reserve you feel you have entered another world where natural forests have been saved and animals protected.

"Preservation of tiger in India is an attempt to preserve the wilderness which is an essential aspect of the human environment. This Indian effort, is therefore, a contribution toward saving the humanity".

Gir National Park

The Gir forest is one of the largest biologically intact continuous tracts of forest land, reserved primarily for the conservation of its native wild fauna in India. The sanctuary has the remnant population of many species, namely the spotted deer, *sambar*, Indian gazelle, *nilgai*, wild boar and the four-horned antelope. The shooting of lions in the area continued unabated up to the turn of the century when a critical stage had been reached and the lion population had decreased to a dangerous level of about 15. Fortunately, a wise decision was taken to stop further shooting of this species and with adequate protection, the population increased to over 20. As described by M. A. Rashid vividly, a new threat arose during the two decades following the independence. With the rapid development of agriculture, vast stretches of woodlands around the Gir forest were cleared for cultivation. Large number of outside cattle numbering about 48,000 used to be brought to the Gir for grazing, besides, the local cattle of the Maldharis in their small settlements called 'nesses' (numbering about 129) all over the Gir area. This created an acute shortage of grazing, and drinking water.

Following recommendations at the Technical Session of the International Union for the Conservation of Nature and Natural Resources held in New Delhi in November, 1969, the problem was specially tackled. The main points highlighted in the discussions were as follows:

a) The Gir Lion Sanctuary exhibits overwhelming evidence of progressive and accelerating degeneration of the indigenous ecosystem, mainly due to overgrazing by domestic livestock entering the sanctuary especially during the monsoon months.

b) In consequence of the loss of grazing and browsing to domestic livestock, wild animals such as *sambar, nilgai, chital,* four-horned antelope and wild boar which constitute the natural food of lions, have become rare.

c) Few large trees now remain in the sanctuary. Natural regeneration is heavily inhibited by domestic livestock, and annual growth is very sparse.

d) In the absence of an abundance of their natural prey, the lions feed on domestic livestock. This has brought the lions into conflict with the owners of the cattle, and occasionally there are cases of poisoning of lions.

e) Due to the above reasons, the whole ecosystem has become unstable and the lion is in imminent danger of being wiped out either by starvation, epidemics or wilful poisoning.

In 1971 the Gujarat Government specially concentrated on the following measures:

1) The establishment of a stable ecosystem under which the lion and other animals could move freely, assured of an adequate supply of their natural prey and food, and protected from poaching, poisoning and the spread of infectious diseases.

2) The bringing about of the socio-economic upliftment of the Gir maldharis.

A number of wildlife and ecological experts and eminent social workers were consulted, and the following decisions were taken:

a) The sanctuary should be permanently closed to grazing by domestic livestock from outside (migrant cattle).

b) The area should be provided with a physical barrier to make the closure effective.

c) The maldharis resident in Gir should be shifted together with their cattle in a phased programme and settled outside the sanctuary, by allotting them land for cultivation as well as common grazing ground for their cattle.

The following guidelines were laid down by the Government:

1) To conserve the Gir habitat and, if possible, improve its health and quality, increase its area and retain its aesthetic values.

2) To encourage wildlife of every kind for its own sake and specifically, the endangered lion.

3) To generally exclude all exotic forms of plant and animal life and preserve all non-human elements of the existing ecosystem in their natural relationship to one another.

4) To reverse or minimise human interference within the ecosystem.

5) To provide a recreation area for tourists.

6) To recast the Working Plan in the interest of wildlife habitat and watershed conservation rather that silvicultural revenue.

7) To make it a model of ecologically sound practices for similar areas.

8) To protect the habitat from overgrazing and lopping.

9) To improve the lot of maldharis and phase their resettlement outside the sanctuary.

10) To unify control of all aspects under a single authority with suitable training in the management of wildlife, nature reserves and national parks.

11) To secure full co-operation of concerned legislators, members of the public and maldharis in all the above steps and measures.

The entire area of the sanctuary has since been fenced by constructing a dry rubble wall of 1 metre height and raising of live hedges on both sides of the rubble wall to prevent any illegal entry of outside cattle into the sanctuary, construction of barricades along the water courses, traversing the periphery of the sanctuary, and providing checkposts across the public roads passing through the sanctuary. Out of the total area of 1,412 sq km of the National Park a core area of 140.4 sq km has been constituted into a *sanctum sanctorum* (National Park) in 1975, increasing this area to 258.71 sq km in 1978. Ultimately, the entire area is proposed to be upgraded into a National Park. The Working Plan of the whole forests has been revised and recast. Out of the 845 maldhari families, 507 were resettled outside in 14 different settlement sites up to March, 1980. The steps taken have shown rewarding results.

The animal population in the area has increased greatly during the last 12 years. The number of lions increased to 205 in 1979.

The elephant

The 1978 General Assembly of the International Union for Conservation of Nature passed the following resolution on the Asian elephant:

Conservation of Indian Elephant Ecosystems:

Concerned at the continuing destruction of elephant (*Elephas maximus*) habitat in India due to ever increasing human pressure.

Aware of the concentration and confinement of elephants in isolated pockets.

Recognising that the elephant's survival depends on conservation and management of the whole ecosystem; the General Assembly of IUCN at its 14th Session, Ashkhabad, USSR (26th September to 5 October, 1978), calls on the Government of India to include a country-wide programme for the conservation of the elephant and its ecosystem as an essential component of the country's next Five Year Plan.

A close study has been undertaken on the subject by the Asian Elephants Specialists Group and their Report (1980) is a valuable document. According to this report the population of elephants in India is as follows:

Region	*Population*
South India	6,000
Central India (Palamau, Singhbhum, Dalbhum)	2,000
North-East India	7,000
U.P.	500
Total	15,500

It would seem that on account of the deterioration and destruction of elephants habitat, even the above population of elephants is finding it difficult to exist in India. It may be mentioned that elephant is now already a rare animal in Bangladesh on account of serious destruction of its habitat during the last three to four decades.

Trade and legislation in animals and animal products

Ivory is one of the biggest and most lucrative items of trade in the field of wild animal products. Indian ivory craft works have been traditionally fine, and the products of ivory carving and handicrafts are in great demand all over the world. Among the other products, special mention may be made of the musk from musk deer of the Himalayas. On an average 3-4 gm of musk (based on about 12 extractions from five deer in the Kufri farm, Himachal Pradesh) is derived from a musk deer in a year. In 1979-80 the black-market price for musk was quoted up to $50,000 per kg despite the fact that synthetic substitutes for musk are available for the perfumery industry in which musk has its main use. Another important wild animal product is the horn of the rhino. The average weight of the horn of one-horned rhino is about 1 kg. In the Middle East where the product is used for dagger handles as a symbol of masculine potency, a single horn was reported to be valued at Rs. 50,000 in 1979. The faith in the mythical properties of the rhino horn was so great that it is said that in some of the South-East Asian countries and in China, people would pay anything from a rupee to ten rupees only for the privilege of touching the rhino horn.

Specific Acts such as the Rhinoceros Preservation Act and the Elephant Preservation Act were framed over the course of years with a view to check the exploitation of certain animal species, as the Indian Forest Act was not sufficient for the purpose. In 1972, the Government of India promulgated the Indian Wildlife (Protection) Act which was a major step towards conservation of wildlife, and regulation and control of trade in wild animals and animal products in India. Chapter V of the Act deals with trade or commerce in wild animals, animal articles and trophies. As the subject is of international importance, a Convention on International Trade in Endangered Species (CITES) has come into existence. The Government of India became a party to the said Convention in 1976. The Convention envisages the regulation on an international scale of the trade in threatened and other species, which any party identifies as being subject to regulation within its jurisdiction for the purpose of preventing or restricting exploitation and needing the co-operation of other parties in the control of the trade. The various appendices of the Convention list such species.

In order to meet the demand of the ivory products for our skilled workers, India imported in 1979, about 13,000 kg of ivory, mainly from Kenya. Hong Kong, Federal Republic of Germany, Tanzania, Uganda, the United Kingdom and Sudan. Out of this a major part of the products of ivory were exported. The ivory trade covered a greater part of the trade in wildlife products in 1979 fetching a sum of Rs. 2.1 crores F.O.B. in exports. Fur trade as also trading in birds of different species and orchids are other important features of wildlife trade in the country. Careful control in the trade of wildlife or its products is obviously important for wildlife conservation. All export, import and re-export is at present channelised in India through the four major ports of Madras, Calcutta, Bombay and Delhi, where the regional offices of the Assistant Directors of Wildlife Preservation are established, with the policy co-ordinated by the Management Authority which is the Inspector-General of Forests in the Ministry of Agriculture.

National parks and man-eaters

As V.B. Singh an eminent wildlife forester has pointed out, the growing human population has brought cultivation right up to the edge of forests. In several cases it is not possible to provide any buffer to the National Parks and sanctuaries. For the villagers, loss of even a small quantity of agricultural produce due to wild animals is a matter of great concern, as most of the farmers barely eke out their living. As pointed out by Singh, in Kheri district of Uttar Pradesh as many as 82 persons were killed by tigers (June, 1982) and several more wounded and injured. By September, 1983, the number of persons thus killed increased to 114. Paying compensation to the bereaved families is no answer. In the case of Kheri man-eaters the villagers threatened to tie up the wildlife warden as a bait, and offered to pay compensation to his family after he was killed by the man-eaters. It is necessary to take action to trap and transfer the offending animals, or kill them. Management of wildlife should involve keeping wildlife population at a certain level in equilibrium with the environment, including culling over and above what the ecological surroundings can hold.

Biosphere reserves

As the Sixth Five Year Plan Document of India points out, with disappearing species and ecosystems under the relentless pressures of an exploding population, the habitats of our species are being repeatedly lost or modified. It is estimated that worldwide slightly over 1,000 animal species and sub-species are threatened with extinction at the rate of one per cent every year, while 20,000 flowering plants are thought to be under similar risk. The world's stock of all species is now estimated at 10 m, of which 8.5 m are still to be identified. Tropical rain forests are considered to contain more species than any other ecosystem, estimated at 2-5 m, but many of these are lost or are grossly disrupted in India in the Western Ghats and in the north-eastern region.

No national park has unfortunately yet been constituted specifically for the preservation of the plant and animal diversity of the tropical rain-forest ecosystems in India. The inestimable value of a number of wild and unutilised relatives of domesticated plants and animals is important for scientific plant and animal breeding. Luckily, India abounds in such wild and semi-wild relatives whose values are still unknown. The rich variety of citrus in N.E. India is an example of one such resource. The diversity of biological organism is a vital resource that should be carefully protected in natural ecosystems, without which many possible evolutionary options for benefitting future generations will be lost. It is known that some primitive varieties of rice collected from Kerala and Mizoram have good genes for resistance to a serious rice threat. Natural ecosystems may represent our only hope for finding the basic material for restoring the health of devastated landscapes such as many of the Himalayan hill slopes. The existing National Parks and Wildlife Sanctuaries are inadequate to cover the ecological diversity of threatened habitats. It is therefore necessary that certain biosphere reserves are created early as proposed by the UNESCO's Man and Biosphere Programmes with the following objectives:

1) To save for the present and future human use for the diversity and integrity of biotic communities of plants and animals within natural ecosystems, and to safeguard the genetic diversity or species on which their continuing evolution depends.

2) To provide areas for ecological and environmental research, including particularly base-line studies both within and adjacent to those reserves, consistent with object (1) above.

3) To provide facilities for education and training. The Biosphere Reserves should comprise not only completely natural ecosystems but also semi-natural established land-use practices. Among such reserves, areas that have outstanding potential for restoration to natural conditions, should also be included. Biosphere Reserves are not meant to substitute established national parks and sanctuaries but may often coincide partly with our national parks and sanctuaries.

After careful consideration, the National Commission on Agriculture in their Report on Forestry in 1976 recommended that "a core area of about 4 per cent of the forest lands in diverse ecological associations should be dedicated to the principal use of nature and wildlife conservation; where only the forces of nature would have their say". Overall it would seem desirable and essential to keep, say 5 per cent of India's forest, in various properly selected ecological zones, under Biosphere Reserves, National Parks and Wildlife Sanctuaries, where nature would have an undisturbed sway for the posterity. There are a number of Preservation Plots in some forests in various places, where vegetation has been left undisturbed for the last many years, but their area is extremely small. A close study of the vegetation of these plots can, however, be rewarding.

Voluntary efforts

It deserves to be mentioned that besides Forest Departments, a number of voluntary organisations like the Bombay Natural History Society, Wildlife Preservation Society of India, Dehra Dun, the World Wildlife Fund, and a number of eminent naturalists like E.P. Gee, Salim Ali, M. Krishnan, Zafar Futehally and others have played an important role in arousing consciousness for wildlife conservation in India.

CHAPTER 11

Tribals and Employment from Forests

The tribals

Over the centuries the people who had retreated into the forests and hill tracts and preserved their simple and distinctive ways of life, came to be known as tribals. Among the large number of studies on tribals, the Dhebar Commission studied the problem in detail in 1960-61, and their Report of the Schedules Areas and Scheduled Tribes is a valuable document on the subject. This Report divides the tribals into four main categories as follows:

1) Those that are living in the remotest corners and for that reason are almost in a primitive stage.

2) Those in the jhumming cultivation stage.

3) Those who have taken to regular agriculture.

4) Those that have been assimilated with other people.

Amongst the first category of people, 22 groups of tribals are known as living in pre-agricultural stage, totalling about 1.5 m people; among these mention may be made of the Jarwas, Onges, Sentinelese, etc., of the Andaman and Nicobar islands. Some of these people are Negrites, who were once widespread in South-East Asia and Oceania. They are simple people, entirely dependent on forests and fishing, etc. Forest area has been generally earmarked for them, and special measures are being taken to establish contact with them, and provide them petty articles of common use as presents, whenever contact can be established with them.

Tribal population

As per 1971 census, the scheduled tribe population in India was about 38 m. The definition of scheduled tribes was somewhat modified as per the Constitution Scheduled Caste/Scheduled Tribe Order (Amendment) Act, 1976. According to this the Scheduled Tribe population of India was 41.1 m in 1976. The Statewise break-up of the Scheduled Tribe population is given in Table 11.1. Figures as per 1981 census have also been given, except for Assam, figures for which are not available. The total tribal population in 1981 in India was 51.6 million, excluding Assam.

To get a clear picture, figures for tribal population have been arranged broadly by regions in this table. The biggest concentration of tribal population in numbers is in a somewhat contigous region in Central India in the States of Madhya Pradesh, Orissa, Bihar, Maharashtra, West Bengal and Andhra Pradesh, totalling 35.4 m in 1981. Gujarat and Rajasthan also have a sizeable tribal population; the north eastern States, Assam (certain districts), Manipur, Meghalaya, Nagaland, Arunachal Pradesh, Sikkim, Mizoram and Tripura have on the whole a much larger percentage of tribal population to the total population, although the total tribal population is comparatively small (44 m in 1976). There are small pockets of tribal population in other States/Union Territories, while Haryana, Jammu and Kashmir, Chandigarh, Delhi and Pondicherry have no scheduled tribe population. The Karnatak tribal population has shown a big increase in 1981, apparently because most of them were left out of count in 1971 and 1976.

The tribal communities have a close relationship with forests. Their customs, religious practices, social fabric and folklore have greatly been influenced by forests. Many of them have been dependent on forests, partially for their food, medicinal herbs, material to build their houses, fuel for cooking as well as lighting and warmth, and fodder for their cattle. At times of food shortages in particular, they depend greatly on the forests for their sustenance. Even in the normal times, the roots, tubers, fruits and flowers collected from forests substantially supplement tribal diet. Tribals enjoy various privileges in respect of cultivation, grazing, collection of fuelwood, collection of minor forest produce, hunting, fishing, etc. in various forests.

Table 11.1: State-wise population of scheduled tribes in lakhs

Sl. No.	State/Union Territory	Scheduled Tribe Population			
		As per 1971 census	Revised as per the constitution SC/ST Order (Amendment Act, 1976)	Percentage of total population	Scheduled tribe population as per 1981 census
1.	Madhya Pradesh	83.87	98.15	23.56	119.87
2.	Orissa	50.72	50.75	23.13	59.15
3.	Bihar	49.33	49.33	8.75	58.10
4.	W. Bengal	25.33	26.03	5.87	30.71
5.	Maharashtra	29.54	38.41	7.62	57.72
6.	Andhra Pradesh	16.58	22.26	5.12	31.80
A)	Sub-total	255.37	284.93	—	357.35
7.	Gujarat	37.34	37.57	14.07	48.49
8.	Rajasthan	31.26	31.35	12.17	41.83
9.	Uttar Pradesh	1.99	1.99	0.23	2.32
10.	Himachal Pradesh	1.42	1.42	4.10	1.97
B)	Sub-total	72.01	72.33	—	94.61
11.	Assam	16.07	16.07	10.99	NA
12.	Manipur	3.34	3.34	31.13	3.88
13.	Meghalaya	8.14	8.14	80.43	10.76
14.	Nagaland	4.58	4.58	88.76	6.51
15.	Arunachal Pradesh	3.69	3.69	78.85	4.41
16.	Sikkim	NA	0.52	24.76	0.74
17.	Mizoram	3.13	3.13	94.28	4.62
18.	Tripura	4.51	4.51	28.98	5.84
C)	Sub-total	43.46	43,98	—	36.76
19.	Tamil Nadu	3.12	4.50	1.09	5.20
20.	Karnataka	2.31	2.62	0.89	18.25
21.	Kerala	2.69	1.93	0.90	2:61
22.	Goa	0.07	0.07	0.82	0.11
23.	Dadra & Nagar Haveli	0.64	0.64	86.49	0.82
24.	Andaman & Nicobar Islands	0.18	0.18	15.65	0.22
25.	Lakshadweep	0.30	0.30	93.75	0.38
D)	Sub-total	9.31	10.24	—	27.59
	Grand total	380.15	411.48	—	516.31

Shifting cultivation

A major problem concerning forests and tribals is shifting cultivation. It may be mentioned that shifting cultivation is not confined to the Indian tribals only. It is practised, with some variations in many tropical and sub-tropical regions of the world.

Serious soil erosion is rampant in the north-eastern Himalayas, closely connected with the practice of shifting cultivation by tribal communities. The same practice is followed by other tribals also, especially in Orissa. Under this system, the forest and undergrowth are cleared and the slash is burnt. Soil is not turned up with plough, and seeds are either broadcast or sown into dibbled holes. Usually two or three crops in as many years are raised on such plots, and thereafter the cultivation shifts to another new plot which is similarly treated. The yield depends on the presence of humus on the original forest floor, and the minerals obtained on burning of the slash. So the same area is cultivated as long as it yields subsistence. Since the forest area is limited, sooner or later shifting cultivation returns to the same area. Yield in the second rotation is less, especially in shorter rotations because the fertility does not build up to the original level, and the soil is subject to natural erosion processes. In every cycle the rotation tends to get shorter as cultivation is done for a fewer number of years in the same area. Increase in population is also responsible for the shortening cycles. The cycle of shifting cultivation gets shorter and shorter, and erosion takes heavier and heavier toll, resulting in deteriorating economic condition of the people.

Shifting cultivation is known by various names in India. In English it is also known as Slash and Burn. In the north-eastern States it is called Jhum. In Orissa it is known as Podu or Dhai, in Madhya Pradesh Penda, etc.

According to a report by S.K. Wadia of the North-eastern Council Secretariat, Shillong, in 1975, to the National Commission on Agriculture, although no systematic study of the extent of shifting cultivation was available, the estimate of the magnitude of the problem in the north-eastern region was as shown in Table 11.2.

According to a recent FAO Study, the land use in the north-eastern region and Orissa, the area of closed and open forest

Table 11.2: Shifting cultivation in north-eastern region

State/ Union Territory	Total area affected by shifting cultivation ('000 ha)	Area under shifting cultivation at one time ('000 ha)	Col. 3 as percentage of Col. 2	Tribal families involved ('000 Nos.)	Area cultivated per tribal (ha)
Arunachal Pradesh	248.58	92.00	37.0	148	0.62
Assam					
(i) Mikir Hills	415.10	54.00	13.0	45	1.20
(ii) North Cachar hills	83.20	15.60	18.5	13	1.20
Manipur	100.00	60.00	60.0	50	1.20
Meghalaya	416.00	76.00	18.2	68	1.12
Mizoram	604.03	61.61	10.2	45	1.37
Nagaland	608.00	73.54	12.1	80	0.92
Tripura	220.79	22.30	10.1	43	0.51
Total	2,695.70	455.05	16.8	492	0.92

Table 11.3: Area estimated by interpretation of Landsat imagery (in 000' ha)

State	Closed forest	Degraded forest	Closed forest affected by shifting cultivation	Degraded forest affected by shifting cultivation	Alpine pastures and scrub land	Non-forest	Snow covered areas	Water bodies	Total geographical area
Orissa	2,832	1,049	622	1,036	—	9,674	—	366	15,579
Arunachal Pradesh	5,702	47	331	463	1,104	193	472	47	8,359
Assam	1,941	599	250	166		4,465		431	7,852
Manipur	227	—	1,329	448		232		2	2,236
Meghalaya	435	160	523	501		627		2	2,248
Mizoram	419	1	1,352	259		64		14	2,109
Nagaland	449	28	244	853		78			1,652
Tripura	286	27	438	184		114			1,049
Total North-eastern Region and Orissa	9,459	862	4,467	2,874	1,104	5,773	472	494	25,505

and the area affected by shifting cultivation based on landsat imagery is given in Table 11.3.

These figures appear to be more acceptable and realistic than the earlier figures. According to these the north-eastern region has 7.3 m ha of closed and degraded forests affected by shifting cultivation, while the corresponding area in Orissa is 1.6 m ha.

Jhumming cycle which was 30-40 years a few decades back, now varies between 10-17 years in Arunachal Pradesh, four to five years in Meghalaya, Mizoram and Tripura, 5-10 years in the Assam Hill districts, six to eight years in Manipur and 6-15 years in Nagaland. Bulk of the forests being owned by villagers or the community, the individual tribal families have little interest in improving the productivity or fertility of the soil, and this constitutes one of the main difficulties of control of shifting cultivation or weaning the tribal families away from this practice. The Dhebar Commission Report (1960-61) said that one of the major problems in the tribal areas is that of shifting cultivation and it is not an ideal method. They thought that the total replacement of this system, if it comes at all, will be a long process. Shifting cultivation is a mixed problem, partly connected with the physical conditions of the land and partly with social customs, traditions and beliefs of the tribals. Any hurried departure may create complications. The only solution of the problem offered by the above Commission was to regulate shifting cultivation on scientific lines so as to limit its disadvantages and promote the fertility of the soil.

According to Borthakur *et al.* (1979), although the system of jhumming was good for the time when it emerged, it is absolutely wasteful at present. The various adverse effects of jhumming according to them are:

1) There has been large scale deforestation resulting in denudation of hill-tops and slopes. This leads to undesirable ecological changes. Further, since the hill-tops are the sources of water, deforestation of hill-tops leads to their elimination.

2) There is large-scale soil erosion due to deforestation and cultivation on hill slopes, without effective soil conservation practices. This, in turn, leads to several adverse effects:

a) Erosion of soil in catchment areas results in silting of reservoirs and streams leading to floods in plains areas.

b) Removal of top soil leads to loss of fertility which is not easily built up. This leads to low productivity and subsequent higher pressure on land.

3) Continuance of the primitive form of agriculture offers very little scope for introduction of modern technology. This, along with loss of fertility has led to such a low level of productivity that the farmers live in near famine conditions. For a particular period, during January to July, they have to live on root crops and jack fruits, etc.

4) The system is labour intensive and with low technology results in low productivity. Further, there is no scope for development of sources of subsidiary income for the farmers. Besides these, which are directly related to agriculture, there are other aspects which adversely affect social welfare. The public health, education, communications and such other basic facilities are difficult to be developed when there is no permanent settlement. Further, large family size is considered to be an asset, since there will be more working force.

There are some good points in jhumming which are worth mention. Use of a dibbling stick for sowing, leads to least disturbance of the soil. The growing of many crops in an intimate mixture helps in the development of a proper crop-canopy, so that erosive rains could be checked to minimise soil erosion. Similarly, the mixture of crops could possibly check the incidence and spread of crop pests and diseases to some extent. But the system on the whole is outdated and disastrous.

State policies on shifting cultivation

Some details need mentioning about Forest Policies of different States in the North Eastern Hills on shifting cultivation. In the Mikir Hill district of Assam, no prohibition is imposed by the State Government on jhumming cultivation in unclassed forests, barring the reserved forests. In Meghalaya, jhum is prohibited in reserved forests, but for other forest areas, there is no Act or Regulation passed by the State on prohibition of shifting cultivation. However, there is a Regulation passed by the Garo Hills District Council, called the Garo Hills District (Jhum) Regulation, 1954 which provides for regulation and control of jhum. Under section 4 of this Regulation, jhumming is prohibited within the following areas:

1) A radius of 400 metres of any water source or catchment area, declared as such by an order of Executive Committee.

2) A distance of 50 metres on either side of the roads of the State Public Works Department and the District Council.

3) Any area which is covered by sal and other valuable trees.

4) Any village or community forest constituted as such under section 17 of the Garo Hills (Forest) Act, 1958.

Since the Executive Committee has not declared any areas as catchment area, nor has applied the Regulation strictly, at present there is practically no control of jhumming in the forests. In Mizoram, there is no control of jhum. As there is no clear boundary demarcation of the reserved forests, jhum is extended at present to reserved forests also. The Government is taking action to consolidate reserved forest boundaries to control jhum to some extent. In Tripura, shifting cultivation is prohibited in all areas of reserved forests and proposed reserved forests. In these areas, *taungya* system of regenerating forest crops, mainly teak and gambhar *(Gmelina arborea)* has been adopted, and in addition to right to jhum crops, the shifting cultivators are paid Rs. 125 per ha by the Forest Department for planting forest trees. There is no other regulation imposed on jhum. But jhum is virtually uncontrolled in the protected forests.

In his discussion with the National Commission on Agriculture, the then Chief Minister of Manipur indicated that introduction of cash crops like potato and maize has increased the intensity of the problem of jhumming, as the increased income from these crops raises the propensity of the farmers to increase the area under jhumming. The National Commission on Agriculture noticed that the problem of jhumming had reached the present proportions because of the system of community ownership. In the case of Naga tribes of Manipur, the custom of tribal ownership of the forests was not prevalent, and jhumming was not as serious as in areas populated by Kuki tribes or Nepali settlements. The National Commission on Agriculture clearly expressed the opinion that both from the point of forest development and economic well-being of the tribals, the shifting cultivation should be regulated, contained and replaced as expeditiously as possible, but any such programme should form a part of the wider plan for tribal welfare.

It has been felt that a simultaneous programme would have to be taken up for afforestation through agri-silvicultural methods, pasture and grassland development, introduction of horticulture crops, as well as plantation crops like rubber, tea and coffee, providing full-time occupation for the tribals in programmes of agri-silviculture, raising plantation crops, development of livestock, etc.

Afforestation through agri-silvicultural methods would meet for a long time to come the psychological urge of the tribals to practise shifting cultivation. Forest Corporations, where set up, should assign due weight to this aspect. Where these programmes are taken up, the tribals should be given homestead lands. Pasture and grassland development should also be taken up by the Forest Departments and areas should be earmarked for the purpose.

The ICAR Research Complex for the North Eastern Hill Region (established in 1975) has carried out major investigations on shifting cultivation. They have expressed the opinion that partial bench terracing on one-third of the slope on the foot hills, and growing horti-pastoral crops on the above one-third area of the slope may be used as immediate alternative to shifting cultivation. Further, on the basis of the quantitative data and economics of the farming system, and potentiality of the region including fodder and fuel resources, a model land use system to be adopted on watershed basis at farmer's level has been suggested.

In Orissa, shifting cultivation is extensively practised by tribals in Koraput, Kalahandy, Phulbhani, Ganjam and Keonjhar districts. In Kalahandy, *pattas* used to be given in the past for such cultivation. In Keonjhar, the Forest Department supposedly demarcates area where the *Juangs* are allowed to carry on shifting cultivation. In practice, however, no such demarcation is made and the *Juangs* cultivate according to their convenience. In this form of cultivation, above 10 per cent slope is prohibited in the State. However, even this restriction is not seriously adhered to. In Andhra Pradesh, about 2 lakh tribals practise shifting cultivation over about 38,000 ha of land mainly in the agency area. Attempts to stop this have generally not been successful. However, a scheme of introducing coffee plantation as an alternative means of livelihood for the tribals has met with some success. In Madhya Pradesh, about 30,000 tribals are estimated to practise shifting cultivation over an area of 18,000 ha. Despite discouragement, the Jond and other tribal people prefer to carry on their age-old method locally known as *dahiya* or *bewar*. The hill Marias of Abujhwar hills and the Halbas of Bastar are among the tribes who continue to practise shifting cultivation. On the other hand, the Bhatras of Bastar and Raipur who till recent years were practising shifting cultivation have given this up. The Baigas of Mandla, Balaghat and Bilaspur districts are gradually taking to settled agriculture. The tribals in the Patalkot Valley still continue shifting cultivation in Madhya Pradesh. In Maharashtra, shifting cultivation is confined to Bhomragarh zone of the Chandrapur district, where about 200 Maria families practise it. But attempt is being made to wean them away from this practice.

In Kerala, Malayaras of the Western Ghats, Kurichians of Wynaad, Mthuvans and Kannikars of Travancore, and Karimpalans of Malabar practise shifting cultivation or *panan*. It is estimated that 10,000 tribals carry on shifting cultivation over about 22,000 ha of land. In the past, no restriction was applied against such cultivation; at present they are required to carry on their cultivation within a limited area, in such a manner that by rotation they can take up the same plot after every seventh year.

Sharma (1978) of the Ministry of Home Affairs, Government of India, has carefully analysed the changing relationship of man and forests with respect to the tribals in India, as elsewhere in other countries. Man appeared in the world as a part of the nature's system like other animals, dependent either directly on the natural produce or other animals who, in their turn, are dependent on the natural produce. Gradually man became a food gatherer and food hunter. The tribal communities like the Sentenalese, Jarawas and Onges of the Andaman Islands, Birhors of Bihar and some tribals in Arunachal Pradesh even today are in this stage of development. Gradually, as man acquired greater skill in food gathering and hunting, his power of exploiting natural resources increased. Then came shifting cultivation, but in earlier years, it had no perceptible impact on the forest resources. For many years, it only meant felling trees in the forests according to the need of the man in place of their natural decay, in an irregular cycle where older trees gave way to new ones according to their respective life cycles. The pastoral communities, notably the Gujjars and Gaddis in the North Western Hills are another variation of the tribals.

In the case of shifting cultivation, the cycle became short, as years went on and population increased so that soil got eroded, leaving behind only the stones and pebbles, where once luxurious forests flourished. This is a common site in Koraput today. From shifting cultivation people switched over to settled cultivation, but slowly, or under agricultural groups, and finally industrial man appeared on the scene. In the early stages of human activity, the local communities owned the land as well as the forest resources near them. With the growing pressure of population, several forest areas got divided between different communities. With the emergence of the modern economies, forest became an important source of wealth, and a major source of raw material for the whole nation. The emergence of the concept of state-ownership of the forest made an important difference to the tribal economy. The forest based tribal economy, the agricultural economy and urban economy *prima facie* represent three different stages in human development and each one of them has to appreciate the other.

There are tribal communities in Orissa and in the North Eastern States, who are entirely dependent on shifting cultivation. But there are also a number of communities who have now taken to settled cultivation or even other modern vocations, yet they are continuing with shifting cultivation as well which merely supplements their incomes.

Tribals and forests

The present scene in the forest regions inhabited by the tribals thus is complex and often widely varying. Amongst many tribals themselves, there are few better off people and many landless poor. It may, however, be also clearly noted that extensive forest areas in India have no tribals. As Sharma (1978) concludes, it is obvious that the development of tribals and development of forests as two co-equal goals are fully compatible and consistent. Certain basic needs of the local communities must provide the solid foundation of rational utilisation of forest resources. The socio-economic conditions of tribal communities should be accepted as an important condition for determining the level of technology and intensity of operations in an area. The basic needs themselves should be assessed in a dynamic frame. The Plans for tribal development should take the forest resources as one of the bases on which tribal economy can progress with confidence. The social services input must be provided on a priority basis in the more backward regions, so that the initial handicaps of the tribals can be removed as early as possible and the resources can be optimally utilised for development of the region as a whole. As no two situations are truly comparable, this will require careful planning at the micro level.

While dealing with the relationship of tribals and forestry, special mention may be made of the overall development in the tribal areas. While naturally the best in the tribal culture and customs should be retained, the general economic improvement in the condition of the tribals will reduce their primitive dependence on forests. An example may be given of the TELCO and TISCO in a typical tribal zone in Jamshedpur. Over the course of years, the neighbouring tribals have much benefitted by employment in major industrial concerns, and their general economic and social conditions have greatly improved. They are much less dependent on forestry or even on agriculture, which fails in a number of years. The establishment of major, medium and small industries specially based on forests in tribal areas can be a major strategy for improvement in the various tribal regions.

As Tiwari (1980), a senior Forest Officer in the Ministry of Home Affairs, has very well summarised:

The tribal communities could subsist for thousands of years with reasonable standard of health and comfortable abode, because forests provided them food, shelter and gainful employment. A variety of new forces have arisen in the forest area which have disturbed this balance. To restore this balance the various commissions and committees have made the following recommendations:

1) One of the Directive Principles of the State policy in the Constitution enjoins that the "State will promote with special

care the educational and economic interest of the weaker sections of the people and in particular, of the scheduled castes and scheduled tribes and shall protect them from social injustice and all forms of exploitation". However three decades of development have not had the desired impact on the socially, economically and educationally handicapped groups. The scheduled tribes remain largely outside the mainstream of development, mainly because of their relative isolation and their exploitation by outside agencies.

2) The Dhebar Commission (1961) recommended that "the Forest Department could be deemed to be charged as a branch of the Government, with the responsibility of participating in the betterment of tribals, side by side with the development of forest. Government should accept as a policy that, as far as possible it will take steps to eliminate the middle-man between the inhabitants of the forest and exploitation of the forests". The Commission felt that "very little attention has been paid to the processing side and the produce is sold in the raw form. The price variation between the raw and processed articles are sometime as great as one to three. Processing can be great source of employment for the tribal people".

3) The Committee on Tribal Economy in forest areas (Hari Singh Committee, 1967), observed that "for the tribals living in forests, the mere subsistence on part-time agriculture and seasonal employment in forest cannot ensure sustenance throughout the year. The best way of diverting the tribals from denuding the forest for the purpose of cultivation is to provide them employment in major and minor forest produce harvesting and collection by eliminating contractors. In predominantly tribal areas, forest must be managed not basically for profit or only for conservation but for furthering tribal interest. This means the revenue will not be the most important consideration but the welfare of the inhabitants of these forests".

4) The National Commission on Agriculture (1976) considered the inter-relationship of forest economy with tribal economy and urged rationality in forestry operations and better utilisation of forest produce. The main recommendations included involvement of tribals in afforestation programme and training them for absorption in all skilled forestry jobs.

5) The Conference of State Ministers of Forest and Tribal

Welfare on the "Role of forest in tribal economy (1978)" recommended that forestry development instead of being planned in isolation should become an integral part of a comprehensive plan for the area in which the needs of local economy should get high priority and consequently influence the choice of species for each area. The conference accepted the need for associating tribals in big plantation programmes giving individuals rights on the trees and their usufruct. The Conference underlined the need for establishment by Tribal Development Departments a strong co-operative base in conjunction with Forest Departments. It also recommended that the tribals in forest villages should be given heritable and inalienable rights over the land which they cultivate without any further loss of time.

6) The National Seminar on Economic Development of Scheduled Tribes (1979) recommended that tribals are ecologically adapted to a forest environment; hence their gainful occupation should be in forestry sector.

7) The then Prime Minister, Indira Gandhi, in a letter addressed to the Chief Ministers suggested the following actions:

a) "In areas where tribals depend heavily on forest for their livelihood, they should be involved in replanting the species that they are already exploiting. A scheme of forest farming should be undertaken.

b) The scheme for contracting away forest area should be replaced or modified to see that every tree should be replaced by another one if not more.

c) A special drive may be launched for purchase of minor forest produce collected by the tribals through co-operatives and State Organisations, so that they are adequately compensated.

d) Programmes such as a tree for every child, nutrition gardens, forest farming, the raising of energy plantation are all potentially valuable mass movements, provided they are formulated thoughtfully and implemented with the involvement of the local population".

8) The Working Group on Tribal Development during Sixth Plan recommended that the local tribal community, which has symbiotic relationship with the forest, should be accepted as partners in the local forestry development efforts in each area. Unless this premise is accepted, and built into the system, it

may not be possible to avoid conflicting situation at the local level. The best protective device for the existing forest and the new addition is to create an interest of the local community in the forest wealth.

9) Management of forest should be in such a manner that it creates confidence among the tribals and gives them a sense of involvement. Rights of tribals in the collection of minor forest produce may be recognised. The tribals should be paid remunerative prices for the minor forest produce collected by them. The aim of management should be production of fuelwood, fodder, fruits, food material and forest produce for other uses. It should also aim at generating gainful employment to the tribals in forestry operations and in forest based industries. Unscientific and indiscriminate exploitation of forest produce results in denudation and dwindling of the resource base, hence tribals must be imparted training to collect only specific quantities without deteriorating the primary base. The existing and new forest based industries should have a dialogue with the concerned State Government for producing additional raw material resources in the areas of tribals. Farm forestry programmes may be encouraged by providing inputs and maintenance allowance during the gestation period of planted crop and ensuring fair price for the produce in advance.

Forest development and tribal economy are actually interdependent. For diverting the rural population from reckless fellings of forests the forestry projects have to be specially designed. So far the forestry operations have benefitted the tribals only as casual wage earners. Minor forest produce having potential to bring about economic revolution of tribals can provide gainful employment to the tribals/rural masses, which can keep them away from deforestation and denudation of existing forests. The remarks of Indira Gandhi, the then Prime Minister of India, while launching the world conservation strategy, "People can be taught to live in peace with nature and themselves only if they are assured of water, shelter and work" are particularly applicable to the tribals. For conserving our forests the basic needs of the people have to be satisfied in a planned manner.

Employment from forests

Forests and the industries based on forests in the secondary and tertiary sector are a major source of employment all over the country. The Sixth Five Year Plan under forestry mentions that it has been estimated that in the primary and secondary sectors, forestry activities generate approximately 240 man days of employment in a year. This comes to less than a million man years of employment. Obviously this is a serious under-estimate. The figures of employment given in the latest available issue of the *Indian Forest Statistics* are also gross under-estimates. According to the publication, *India's Forests* (1980) the personnel employed on 1st April, 1977 in forestry organisations was as follows:

Personnel employed in forestry organisations

a) Central Organisations:	
Gazetted	712
Non-Gazetted	3,442
b) States and Union Teritorries of which (Forests Departments only)	
i) Professional	2,581
ii) Sub-Professional (Non-Gazetted)	115,227
iii) Non-Technical (Gazetted and Non-Gazetted)	28,149
Total	145,957

India's forests yielded a revenue of Rs. 472 crores in 1980-81, and an amount of Rs. 318 crores was spent under the normal and Plan Schemes of the Forest Departments in the same year. Forestry activities are largely labour intensive, specially in backward areas. Assuming half of the expenditure of Rs. 318 crores, i.e. an amount of Rs. 159 crores was spent on labour at the rate of Rs. 8 per day for 300 working days, or Rs. 2,400 per annum, this leads to an employment of six lakh workers. Similarly, at least two million workers may be estimated to be employed in the extraction, conversion and transport of timber. At least 10 per cent of the present tribal population of say 50 m, i.e. about five million directly derive their livelihood from forests. The various forest industries provide another gainful source of employment. It is estimated that about 34 m cattle grazed in the forests in 1975. Assuming one man looked after 10 cattle grazing in the forest, the total number of men looking after these cattle comes to 3.4 m. Overall it is estimated that at least 8-10 per cent of the population of the country, including the families of the dependents depend upon their livelihood from the forests and forest industries of India. This number is capable of being considerably increased if major forest development programmes are initiated.

CHAPTER 12

Forest-based Industries

Forest utilisation

The process of harvesting, converting and disposal of wood and other forest products is called forest utilisation and is an important branch of forestry. Forest produce can be broadly classified into wood, i.e. timber and fuel or what has often been called the major forest produce, and non-wood products, sometimes though erroneously called minor forest products. Forest utilisation deals with the process of felling and conversion of trees in the forest or outside, transport of wood in different types of terrain by various modes of transport, storage of wood, setting up of sawmills and wood workshops and systems of extraction, disposal and organisation of forest labour, as also scientific extraction and utilisation of all non-wood products.

Percentage of utilisation

In the developed countries, according to some sources not more than 50 per cent of wood from the forest comes out as rough lumber, slabs and edglings. The broad break-up is estimated somewhat as follows:

Item	*Percentage*
Rough lumber	30
Slabs and edglings	20
Trees too defective or stunted to cut	10
Left in the woods in the form of stumps, etc.	15
Bars	10
Saw dust	10

Loss in seasoning	5
Total	100

The overall percentage conversion in India may be better due to heavy demand and cheaper labour, though the intensity of conversion varies considerably from place to place. Where forests are close to utilisation points, the percentage of conversion is much more intensive, while in forests which are away from the source of utilisation or with inadequate transport, the percentage of utilisation is less.

Forest utilisation also deals with the structure of wood of various forest species, the physical and mechanical properties of wood, the chemistry of wood and wood components, wood-water relationships and defects of timber. Other branches of forest utilisation are seasoning of wood and wood preservation, besides composite wood and modern timber engineering techniques.

Wood is used by man from the cradle to the grave. Weight for weight, timber is as strong as iron, and five to six times stronger than cement-concrete. It is superior to the other two mentioned materials in thermal insulation, sound absorption, electrical resistance, etc. It also has a high salvage value as compared to the other two materials. Besides these properties, wood is a national asset of very great value, because it comes from a renewable crop, and is therefore, inexhaustible in supplies, while iron and steel have a limited availability. To select wood for a particular purpose requires an accurate knowledge of the qualities required, and reliable information as to the woods possessing those qualities. The important features usually concerned in the selection are: (a) hardness, (b) strength, (c) specific gravity, (d) toughness, (e) anatomical structure, (f) flexibility, (g) shape and size of tree, (h) elasticity, (i) colour, grain, figure, etc., (j) adaptability or otherwise to seasoning, (k) adaptability to working with tools and/or machines, (l) natural durability and adaptability to treatment of preservatives, and (m) freedom from defects.

Integrated utilisation of wood

Gleisinger in his book *Coming Age of Wood* laid great stress on the integrated utilisation of wood and other forest products for industries. How best to achieve this is an important question for consideration. In the free trade, the principles of supply and demand determine this. Take for instance the utilisation of fir and spruce sleepers at a place like Yamunanagar (Haryana) which is one of the big markets for these. Few of the selected straight grained sleepers are picked out for the battery separator industry at a comparatively high price. Out of the remaining, the best are selected for high class packaging, including special packaging such as for tobacco. The next grade timber is used for inferior packaging. Some of the smaller pieces are used for such purposes as making of slate frames, etc. The saw-milling scrap is sold for pulping purposes to the local paper mills. Even the sawdust is utilised. This still leaves the considerable part of fir and spruce wood left in the forests at the time of conversion, out of account. With modern logging, extraction and floating of fir/spruce logs, the waste on this account is greatly reduced. The pattern of wood utilisation in any industrial town would be somewhat similar. Growth of industries has helped better and more and more complete utilisation of forest products.

Improved logging

Improvement in conversion of trees into timber and fuel and their transport has been a constant feature of forest management during the last 80-100 years. In particular, a logging training centre was started in 1957 at Batote (J & K); this work was extended to four centres in 1965 with the help of an FAO/UNDP Scheme. A full Logging Development Institute has recently been established at Dehra Dun.

Mention may be made here of the twisted pine of Kumaon in Uttar Pradesh. About 1956, besides the limited local firewood demand, practically there was no use for this, and it was felt by the Forest Department that if such forests were to be regenerated, which was necessary as they were becoming mature and over-mature and spent up for resin also, money will have to be spent in felling and burning the material. It was, therefore, considered that it would be worthwhile to offer the twisted *chil* at a nominal price to a pulping industry. The consideration of the matter took time and in a few years it was found that the twisted chil could partly give some useable timber. The original formula of supply to the industry was thereupon considerably modified.

Paper and paperboard

One of the most important uses of wood and bamboo is in making paper and paperboard all over the world. In 1970 it was estimated that out of the total turnover of forest based industries in the world, about half came from the paper and paperboard industry. Paper making originated in China. According to the Chinese the credit for this development goes to T' Sai Lun (about the year 105 A.D.). Up to the end of 18th century, all paper was made by hand. Although the quality was usually high, the output was low. As is well known, paper is an essential tool of modern education, culture, commerce, industry and Government.

As the population and literacy increased, efforts were made to replace the hand-made method of making paper by machinery. An important step was taken in 1799 by Louis Robert making a paper machine, which was later improved by a London firm of stationers owned by two brother Henry and Sealy Fourdrinier. After several trials a machine was created at Frogmore in 1803. By 1830, one half of the paper made by hand in the United Kingdom was made on Fourdrinier paper machines. In 1844, Keller with the help of Voelter in Germany developed the process for the manufacture of mechanised wood pulp. In 1854 Watt and Burgess of the United Kingdom patented a process for producing pulp from wood by treatment with caustic soda. The chemical wood pulp had a characteristic altogether different from that of the mechanical pulp.

Much of the structural portion of a plant is composed of cells. Cells are often too small to be seen by the naked eye. Their walls are composed of 'cellulose', a chemical compound with the empirical formula $C_6H_{10}O_5$. Cellulose is a fibrous substance insoluble in solvents, and is resistant to dilute alkali and dilute acids. Closely associated with the cellulose are non-fibrous carbohydrates, called hemicellulose and an aromatic amorphous compound called lignin, and in addition small quantities of substances like tannins, resins, waxes and mineral substances. The plant cells, like minute threads in shape, have their length several times greater than their breadth and are called fibres. The fibre dimensions and chemical composition of typical conifers are as follows:

1) Mean fibre length, in mm		3–3.5
2) Mean fibre diameter in microns		30–40
3) Mineral matter	%	1–2
4) Extractives (in water alcohol, etc.)	%	4–12
5) Cellulose	%	40–45
6) Hemicellulose	%	15–20
7) Lignin	%	26–30

Paper making in India

In the latter part of the 18th century, the art of paper making had spread to India from China. Of course the ancient Indian records are on the leaves of the tree of *Bhojpatra* or *Betula utilis*. The history of modern paper making in India started about 1830 with the installation by Dr. Carey, a foreign missionary, of the first paper machine at Serampore in West Bengal. In 1867, a paper mill was established at Bally in West Bengal to work on a commercial scale. The Upper India Couper Paper Mills, Lucknow was established in 1882, and the Titagarh Paper Mills Ltd., Titagarh in West Bengal in 1884. These mills used *sabai* grass (*Eulaliopsis binata*) as the fibrous raw material. By 1912, William Raitt, a pioneer scientist of the Forest Research Institute, Dehra Dun had established that bamboo could be used for the production of paper. With the utilisation of bamboo, the production of paper shot up in India. From 27,000 tonnes in 1924-25 the production increased to 39,600 tonnes in 1930-31, to 87,000 tonnes in 1940-41 and 107,600 tonnes in 1950-51.

PROCESS OF MAKING PAPER

Essentially paper making consists first.of pulping the fibrous raw material, i.e. isolating cellulosic fibres from the rest of the material. The following processes are used:

1) Mechanical process
2) Chemical process
    i) alkaline process;
    ii) acidic process.
3) Semi-chemical process

Thereafter the pulp is cleaned and bleached, followed by stock preparation, comprising of beating, sizing, loading, colouring, using necessary additives, sheet formation and drying the sheets of paper.

CLASSIFICATION OF PAPER

Paper is classified into two broad categories—paper and paperboard, on the basis of weight per unit area of the sheet. The dividing line is usually the weight of 250 gm/sq metre. Some of the well-known categories of paper are airmail paper, art paper, bible paper, blotting paper, bond paper, book paper, cigarette paper, cover paper, drawing paper, grease-proof paper, imitation art paper, kraft paper, ledger paper, newsprint and vegetable parchment, etc. The various categories of paperboard include duplex boards, strawboards and millboards.

RECENT PROGRESS OF PAPER INDUSTRY

Progress of paper industry in the post-independence India has been rapid, though not commensurate with the overall requirements of the national economy and the potential. The production of paper and paperboard during the last 30 years in India is given in Table 12.1.

In 1981, there were 138 large and small paper mills, and their statewise location is given in Table 12.2.

Mills above 20,000 tonnes capacity accounted for 70 per cent of installed capacity of the paper industry in the country in 1981. In 1980-81, India imported about 80,000 tonnes of paper. The value of imports of pulp, paper, paperboard and manufactured products thereof, etc., during the last 10 years is given in Table 12.3.

The per capita consumption of paper in India compared to some other countries in the world is shown in Table 12.4.

The revenue collected as excise duty by the Government of India during the past ten years is given in Table 12.5.

About 40 per cent of the excise duty collected was transferred to the States divisible pool. According to M.K. Raina, Chairman, Indian Paper Makers' Association (1982), the paper industry contributed approximately Rs. 2,700 per tonne of paper produced in the form of various taxes.

With the rapidly increasing population, and expected rise in literacy, the demand of paper and paperboards is expected to

Table 12.1: Paper and paperboard—capacity and production in India (lakh tonnes)

Year	Capacity	Production	Capacity utilisation %
1951	1.37	1.32	96.4
1952	1.48	1.37	92.6
1953	1.51	1.40	92.7
1954	1.74	1.55	89.1
1955	1.86	1.85	99.5
1956	2.15	1.97	91.6
1957	2.52	2.10	83.3
1958	2.69	2.53	94.1
1959	3.21	2.94	91.6
1960	4.00	3.45	86.3
1961	4.10	3.64	88.8
1962	4.34	3.88	89.4
1963	5.02	4.63	92.2
1964	5.56	4.91	88.3
1965	6.44	5.37	83.4
1966	6.44	5.85	90.8
1967	7.01	6.09	86.9
1968	7.30	6.39	87.5
1969	7.30	7.01	96.0
1970	7.68	7.60	99.0
1971	9.54	7.85	82.2
1972	9.54	7.85	82.2
1973	9.67	7.75	80.1
1974	10.09	8.27	82.0
1975	10.68	8.12	76.8
1976	11.37	8.80	77.4
1977	12.65	9.37	74.1
1978	13.80	10.06	93.1
1979	15.38	10.47	68.1
1980	16.56	11.13	67.2
1981	18.17	12.35	68.0
1982	N.A.	12.36	68.0
Annual Growth Rate (%)			
1951-61	19.9	17.6	91.0*
1961-71	12.0	11.1	90.0*
1971-81	10.2	5.8	76.9*

***Denotes the average capacity utilisation ratio (%) during the decade.**

Table 12.2: Statewise location of paper mills in India

State/Union Territory	Total No. of Units	Large Units		Small Units		
		Capacity over 20,000 TPA	Capacity 10,000 to 20,000 TPA	Capacity 5,000 to 10,000 TPA	Capacity 2,000 to 5,000 TPA	Capacity up to 2,000 TPA
Gujarat	26	1	2	5	6	12
Maharashtra	24	2	3	4	10	5
Uttar Pradesh	19	1	nil	3	3	12
W. Bengal	14	3	1	4	2	4
Haryana	11	1	1	3	3	3
Karnataka	9	2	1	2	2	2
Andhra Pradesh	8	4	nil	2	2	nil
Tamil Nadu	5	1	1	2	1	nil
Madhya Pradesh	5	2	nil	nil	1	2
Bihar	3	1	1	nil	1	nil
Orissa	3	2	1	nil	nil	nil
Punjab	3	nil	2	1	nil	nil
Rajasthan	2	nil	nil	1	1	nil
Assam	2	1	nil	nil	nil	1
Kerala	2	1	nil	nil	1	nil
Chandigarh	1	nil	nil	nil	nil	1
Pondicherry	1	nil	nil	1	nil	nil
Total	138	22	13	28	33	42

Table 12.3: Paper and paperboard Imports (Rs. in crores)

	Mainly pulp	Paper, paperboard and manufactures	Total
1970-71	12.3	25.1	37.4
1974-75	9.8	59.5	69.3
1975-76	16.0	57.7	73.7
1976-77	6.1	61.1	67.2
1977-78	21.2	81.8	103.0
1978-79	41.7	104.7	146.4
1979-80	30.3	155.3	185.6
1980-81	14.8	175.9	190.7

Table 12.4: Per capita consumption of paper: 1980 (per annum)

Country	Consumption kg	Country	Consumption kg
U.S.A.	272	Israel	79
Sweden	205	Iran	15
Canada	192	Thailand	11
Switzerland	168	U.A.R.	10
West Germany	155	Iraq	9
Japan	153	Indonesia	3
U.K.	122	India	2
Hong Kong	121	World average	40

Table 12.5: Revenue from union excise duty on paper

	Revenue Rs. in crores	% share to total receipts
1970-71	24	1.4
1975-76	48	1.2
1976-77	86	2.1
1977-78	90	2.1
1978-79	109	2.1
1979-80	149	2.4
1980-81	174	2.7
1981-82	186	2.5

rise to 35 lakh tonnes per annum by the end of the century. The National Commission on Agriculture in their interim report on *Production Forestry—Man made Forests* (1972) had also suggested that India should be in a position to enter the export markets aggressively for paper and paper products in the nineties.

Causes of inadequate growth

The growth of the paper industry has been inadequate principally for the following reasons, besides others:

1) Low profitability of the paper industry.

2) Lack of clear-cut policies, and poor implementation where policies have been laid down.

3) Non-implementation of suitable projects where forest raw materials for paper are abundant e.g. Bastar.

4) Inadequate supply of raw materials.

It may be mentioned that the Nagaland Pulp and Paper Project in public sector initiated in 1971 originally estimated to cost Rs. 19.6 crores by the Hindustan Paper Corporation has gone into production in 1982 at a revised cost of about Rs. 80 crores. Unfortunately the project is so badly located, that the more paper it produces, the more losses are incurred.

Forest policy vis-a-vis industry

It is worth mentioning that a paper on forest policy presented to and accepted by the 30th meeting of the National Development Council, presided over by the Prime Minister in December, 1973 inter-alia stated that the supply of forest raw materials for industries was insufficient even with the very low standard of consumption, and there was lack of a well defined forest industrial policy. For the same reasons, the paper said that the country was importing sizeable quantities of products of forest based industries. The paper further emphasised that the forest policy should be specially oriented to meet the requirements of forest based industries, and time bound programmes formulated and implemented for eliminating imports of products of forest based industries and increasing exports of such products.

With plenty of sunshine, long growing season and sufficient rainfall in many areas of the country, and extensive wastelands and forest areas, it should be possible to supply large quantity of forest raw materials for pulp and paper industry at reasonable cost. Unfortunately this position has not existed for various reasons.

Raw material mix

According to the NCA report (1976), the past and projected percentage of consumption of various cellulosic raw materials in the pulp and paper industry in India is as follows (Table 12.6):

Table 12.6: Percentage of consumption of raw materials in Indian pulp and paper industry

			(Projected Low Estimates)			
	1958-59	1970	1980	1985	2000	1980*
Bamboo	70	51	32.0	21.1	14.8	61
Hardwood	4	24	45.4	46.0	49.4	27
Softwood	1	3	16.2	16.4	24.3	2
Bagasse	3	5	0.8	0.8	2.3	—
Imported pulp	5	Neg	—	—	—	—
Agricultural residue, waste paper and others	17	17	5.6	5.7	8.7	10

*The last column in the above Table has been added based on the estimates made by S.R.D. Guha, Director, Central Pulp and Paper Research Institute, Dehra Dun.

It would be seen that while the NCA envisaged that bamboo may amount to an aggregate of 32 per cent in the total raw material mix of the paper industry in 1980, according to Guha's estimate, bamboo still constituted 61 per cent of the total raw material of the paper industry in India.

The actual percentage of bamboo and hardwoods used by some bigger paper mills during the year 1977-78 to 1979-80 as given by Y.K. Aggarwal is given in Table 12.7.

Table 12.7: Bamboo-wood mix of major paper mills

Name of the Company	1977-78		1978-79		1979-80	
	Bamboo %	Wood %	Bamboo %	Wood %	Bamboo %	Wood %
Orient Paper	81	19	77	23	75	25
Ballarpur Industries	55	45	58	42	58	42
Andhra Paper	81	19	68	32	73	27
Titagarh Paper	80	20	79	21	77	23
Straw Products	100	—	100	—	100	—
Sirpur Paper	89	11	75	25	N.A.	N.A.
Rohtas Industries	76	24	74	26	85	15
West Coast Paper	66	34	50	50	47	53
Seshasayee Paper	65	35	46	54	45	55
Mysore Paper	73	27	77	23	76	24
Bengal Paper	63	37	63	37	60	40

Cost of forest raw materials

While the cost of bamboo delivered air dry of one of the major paper mills in India in 1967-69 was Rs. 100 per metric tonne this cost increased to Rs. 190 in 1973-74, to Rs. 350 in 1975-76 and to Rs. 472 in 1979-80. The cost of hard wood which was Rs. 100-110 in 1975-76 increased to Rs. 234 per metric tonne in 1979-80, and to Rs. 600 per metric tonne in 1982. The cost of bamboo and wood delivered at the mill site of some of the important paper mills during the years 1977-78 to 1979-80 as given by Y.K. Aggarwal is shown in Table 12.8.

The costs have increased appreciably further during the years 1981-84 due to general rise in prices, and especially due to increase of transport costs. Not only are the costs of forest raw materials high, because of generally irrational supplies from long distances and working over extensive scattered areas, the supplies are also uncertain. This position needs to be remedied at an early date.

Table 12.8: Cost of bamboo and wood delivered to important paper mills during 1977-80 (Rs. per metric tonne)

Company	Bamboo			Wood		
	1977-78	1978-79	1979-80	1977-78	1978-79	1979-80
Orient Paper	368	403	472	177	195	234
Ballarpur Industries	172	189	205	143	217	228
Andhra Paper	309	348	359	161	192	226
Titagarh Paper	290	346	395	207	225	235
Straw Products	264	294	310	—	—	—
Sirpur Paper	262	313	N.A.	188	265	N.A.
Rohtas Industries	337	369	474	189	216	227
West Coast Paper	228	279	347	220	239	278
Seshasayee Paper	194	363	400	260	324	395
Mysore Paper	187	176	227	122	154	183
Bengal Paper	381	485	534	273	337	400

Forest areas on leases to paper mills

Considering the major difficulties encountered by the industrial units, the Karnataka Government has accepted the proposal to make available forest areas for raising plantations to major forest based industries like the Mysore Paper Mills, West Coast Paper Mills, M/s. Harihar Polyfibres and the like. The proposals for leasing revenue lands transferred to the Forest Department for raising captive industrial plantation is also under consideration of the Karnataka Government. According to the *Economic Times* of 3rd October, 1981, the Maharashtra Government has permitted Modis to take up extensive commercial afforestation in Konkan region for their Rs. 1,335 m plant to manufacture high wet modulus fibre, which is not so far manufactured in India.

The Gujarat State Forest Development Corporation was preparing in 1981 a project report for Rohit Pulp and Paper Mills and the Central Pulp Mills to raise plantations. Bamboos are also proposed to be raised on farm lands in Gujarat with financial support from the consuming pulp and paper industry, which may ultimately obtain refinance from National Agricultural Bank of Rural Development.

For a major break-through in ensuring sufficient quantities of forest raw materials to the pulp and paper industries at a reasonable cost, the forest areas and wastelands of high productivity should be leased to the paper mills, if necessary in joint sector, wherein the latter through professional forest officers of sufficient experience should raise intensive plantations by putting in large inputs including intensive soil working, irrigation and fertilisers. Paper mills should also join in extensive social forestry operations within their catchments, and in forest research programmes.

Mill catchments

It is interesting to note that if a plantation yielding 10 metre^3/ha of wood a year is laid out in a circular area with the pulp mill in the centre, a mill producing 400 tonnes of paper per day or 1,32,000 tonnes per year should have to transport its pulp wood a distance not greater than 15 km or so. Such a circular plantation would contain only 70,000 ha of forest land. Even allowing a somewhat bigger distance of 20 or 25 km the possibilities of economic supply of raw materials in such a situation offer a most attractive proposition.

Suitability of hardwoods for pulping

Mention may be made of the work of N.D. Mishra of Sirpur Paper Mills on hardwood pulping and paper making. Mishra has classified good number of Indian hardwoods according to their suitability for pulping for making bleachable pulp by the craft process. He has graded a number of these species in four grades as per Table 12.9.

A list of indigenous fast growing species prepared by I.M. Qureshi, then Central Silviculturist at the Forest Research Institute, Dehra Dun is given in Table 12.10.

Tropical pines are ideally suited for paper making and are fairly fast growing. In India some plantations of tropical pines have already been raised in various suitable areas. The plantations need to be greatly extended as an important raw material source for paper and newsprint. For an efficient paper industry, it is essential that raw materials should be of uniform size and

Table 12.9: Classification of suitability of tropical hardwoods for making bleachable grade pulp by Kraft process

Sl. No.	Name of the species	Total No. of suitability points as per Grading Method (PPI, June, 1973)
	Grade I (Above 700 points)	
1.	*Chloroxylon swetania*	837
2.	Eucalyptus hybrid	806
3.	*Dendrocalamus strictus*	787
4.	*Lannea grandis*	765
5.	*Anogeissus latifolia*	765
6.	*Albizzia lebbek*	762
7.	*Sterculia urens*	762
8.	*Sesbania grandiflora*	750
9.	*Pterocarpus marsupium*	734
10.	*Prosopis juliflora* (young 3-4 years)	719
11.	*Garuga pinnata*	718
12.	*Acacia auriculiformis*	712
13.	*Tectona grandis* (young up to 8 years)	707
14.	*Gmelina arborea*	703
	Grade II (700 to 500 points)	
15.	*Pongamia pinnata*	687
16.	*Terminalia belerica*	662
17.	*Hibiscus canabinus* (whole Kenaf)	662
18.	*Schleichera trijuga*	653
19.	*Boswellia serrata*	571
20.	*Butea monosperma*	562
21.	*Dalbergia paniculata*	546
22.	*Prosopis juliflora* (over 4 years old)	506
	Grade III (500 to 350 points) (Not suitable for bleachable grade pulping)	
23.	*Terminalia tomentosa*	456
24.	*Cleisthanthus collinus*	437
25.	*Gliricidia maculata*	390
26.	*Xylia xylocarpa*	362
	Grade IV (Below 350 points) (Not suitable for bleachable grade pulping)	
27.	*Acacia sundra*	237
28.	*Lagerstroemia parviflora*	224
29.	*Diospyros melanoxylon*	not workable
30.	*Madhuca latifolia*	

Table 12.10: Indigenous fast growing species

Name of species	Age (years)	M.A.I. metre^3/ha
Duabanga sonneratioides	47	18.9
	26	12.5
Alnus nepalensis	22	16.3
Terminalia myriocarpa	8	15.3
Phoebe hainiana	19	7.4
Evodia meliafolia	11	9.9
Michelia champaca	8	18.2
Chikrassia tabularis	32	7.7
Lophopetalum fimbriatum	17	15.2
	22	11.6
Casuarina equisetifolia	5	15.1
Shorea robusta (Coppice Quality A)	30	11.0
Cedrela toona	5	18.5
	9	15.5
	14	16.8
Trewia nudiflora	13	12.7
	18	9.7
Artocarpus chaplasha	10	16.4
	14	19.8
	19	15.5
Dalbergia sissoo	11	33.7
Gmelina arborea	3	21.6
	6	23.0
	11	15.3
Tectona grandis	10	12.2
Michelia oblonga	14	17.5
Bischofia javanica	7	13.2
Broussonetia papyrifera	10	21 to 30
Bucklandia populnea (Kurseong Division, West Bengal)	15	9.4
	21	15.2
Terminalia tomentosa (Buxa Division, West Bengal)	4	10.0
	7	14.9
	12	16.9
Kydia calycina	10	10.5

quality, otherwise the expenditure on chemicals is high and wasteful, and recovery of chemicals and energy is comparatively less, leading to higher cost of paper making. It may be mentioned that there need be no environmental hazard at all in raising pulpwood plantations, as suitable mixtures of trees, or of trees and shrubs can always be evolved. Areas for the need of villagers can also be reserved, and developed intensively for plantations of fuel, fodder, small timber and other needs in contiguous places.

Sixth Plan targets

The supply-demand position for paper and paperboard for the Sixth Plan is given in Table 12.11.

Table 12.11: Supply-demand position for paper and paperboard

('000 tonnes)

Sl. No.	Item	1979-80	1984-85
1.	Demand	1,100	1,540
2.	Production	1,050	1,500
3.	Imports	50	40

The Sixth Plan target for production of paper and paperboard is laid down at 1.54 m tonnes by 1984-85, with a capacity of 2.05 m tonnes.

Newsprint

Newsprint is an extremely important item, as newspapers are virtually the torch bearers of democracy. Even the Third Five Year Plan placed the target of 1.5 lakh tonnes of newsprint production. Unfortunately, the targets for newsprint production have not been met so far. The supply-demand balance for newsprint for 1979-80 and projections for 1984-85 are given in Table 12.12.

The present consumption of newsprint is of the order of 3.5 lakh tonnes. According to the Sixth Plan, it was estimated that the demand would increase to 5 lakh tonnes by 1984-85. Capacity for newsprint is expected to increase to 2.3 lakh tonnes and

Table 12.12: Supply-demand balance for newsprint

('000 tonnes)

Sl. No.	Item	1979-80	1984-85
1.	Demand	359.5	500
2.	Production	47.5	183
3.	Imports	312.0	320

production to 1.8 lakh tonnes by 1984-85, and imports of newsprints will have to continue during the Seventh Plan period also. The Kerala newsprint project with an annual installed capacity of 80,000 tonnes of newsprint and Newsprint Project of Mysore Paper Mills with a capacity of 75,000 tonnes per annum have gone into production. Raw materials for newsprint need to be planned on a much more rational and ambitious scale than hitherto. Steps have also been taken to create newsprint capacity based on bagasse. With proper development of forest and other raw materials, it is possible to meet the entire increasing demand of newsprint industry in India, and even build up export in the next 10-20 years.

Rayon pulp

Another important product of forest industries is rayon pulp made from wood. This offers special advantages of quality in textile and tyre industries. The capacity and production in 1979-80, and the Sixth Plan targets for rayon fibres are given in Table 12.13.

Table 12.13: Capacity and production target of rayon fibre (in tonnes)

	1979-80		1984-85 Targets	
	Actual capacity	Anticipated production	Capacity	Production
Viscose filament yarn	41,100	41,800	43,000	43,000
Viscose staple fibre	97,400	84,500	1.50,000	1,20,000
Viscose tyre cord	21,000	15,000	21,000	21,000

In the 1960's, 50,000 to 70,000 tonnes of rayon grade pulp was imported annually to meet the internal requirements of the industry. With the development of indigenous capacity, imports of this item have practically ceased. Among the principal manufacturers are M/s. Gwalior Rayon Silk Manufacturing (Wvg) Co. Ltd., with an installed capacity of rayon grade pulp manufacture at Mavoor (Kerala) of 72,000 tonnes, and at Harihar (Karnataka) of 58,000 tonnes per annum, and South India Viscose Ltd. (Sirumugai, Coimbatore district) of 4,000 tonnes rayon yarn and 11,000 tonnes of staple fibre. Andhra Pradesh Rayon Ltd. have also recently come into production at Eturnagaram in Warangal district (Andhra Pradesh) with an installed capacity of 25,000 tonnes of rayon grade pulp per annum.

Rosin and turpentine industry

The production of pine resin has been referred to earlier. From resin, rosin and turpentine are produced by distillation. Rosin is used in paper and soap, industries. A large number of products are also made from rosin. Some of the important derivatives of rosin are given in Table 12.14.

Good number of products are also made from turpentine including large number of chemical derivatives. These include synthetic pine oil, camphor, terpineol, vormeol, voneol acetate and pine tar. Large number of chemicals are based on these various products which find a significant use in the industry in India today.

Bidi industry

Tendu leaves have been referred to earlier as an important raw material for the *bidi* industry. *Bidi* making which is a cottage industry in real terms provided employment to a very large number of people. It is estimated that at present 30 lakh people are engaged in *bidi* manufacture. The All-India production of *bidis* is estimated to be 1·30 crore pieces every day, and tobacco and *tendu* leaves consumption are about 80,000 tonnes and 3,50,000 tonnes per year respectively. The Government of India earns by income tax an amount of Rs. 30 crores per year from this source. The cost of tobacco and *tendu* leaves consumed in the *bidi* industry is estimated by D.N. Tiwari at Rs. 100 crores

Table 12.14: Derivative of Rosin

Type of rosin		Uses
1. Unmodified rosin	Metal salts of sodium*, lead*, manganese*, cobalt*, zinc*, calcium*, iron*, and copper*	Soap sizing material, driers, varnish, resins and fungicide
	Esters of methyl alcohol, ethylene glycol, diethylene glycol, glycerol*, pentaerythritol, and other polyols	Plasticisers, tackifiers and resins for varnishes, lacquers and plastic compositions
	Glycerol esters of maleated rosin*	Varnishes and lacquers
	Glycerol and pentaery thritol esters of rosin modified with formaldehyde* and P.F. condensates*	Varnishes and lacquers
2. Hydrogenated rosin	Esters of methyl alcohol, ethylene glycol, diethylene glycol, glycerol, pentaerythritol and other polyols	Plasticisers, tackifiers, resins for varnishes and lacquers
3. Disproportionated rosin	Sodium soap	Emulsifier for synthetic rubber manufacture
4. Polymerised rosin	Metal salts of zinc and calcium. Esters of glycerol and pentacrythritol. Glycerol of maleated product. Glycerol and pentaerythritol esters of polymerised rosin modified with P.F. condensates	Varnish resins
5. Other products	Methylolated rosin, oxonated rosin (hydroformulated rosin) Rosin alcohol. Rosin amine	Varnish constituent, polyesters and varnish constituents. Adhesive fungicides, bactericides, corrosion inhibitors and surfactants

*These products are manufactured in India.

each. The excise duty is about Rs. 35 crores per year. The industry uses wagon movement to the tune of 20,000 wagons per year and the railway freight paid by the industry is about Rs. 8 crores per year. At the average rate of Rs. 5 per 1,000 *bidis*, the wages paid to the workers are estimated to amount to Rs. 200 crores per annum. Practically no infrastructure is involved. Organisation of *bidi* workers and the industry on a co-operative basis has been initiated in some places, and needs to be widely encouraged and adopted.

Wood panel products

COMPOSITE WOOD AND IMPROVED WOOD

Wood has been a favoured raw material for different purposes because of the ease of working, good strength, elastic, thermal and other properties, and because of the wide choice it provides to meet different structural needs. The use of wood has, however, some disadvantages namely (a) natural growth defects, such as knots, spiral grains, etc., (b) hygroscopicity with its attendant defects like alternate swelling and shrinking, induced by changes in atmospheric conditions, (c) lack of strength balance due to anisotropy, and (d) lack of strength in compression and shear, non-uniformity, etc.

A number of processes have been developed to get over wholly or partially some of these defects. These processes consist of developing larger pieces of wood from relatively small pieces or in treating and modifying wood under pressure, heat and chemicals. These processes also help in utilising waste wood, and wood of inferior species.

COMPOSITE WOOD

Composite wood is a general term for built-up, bonded products consisting of natural wood, and chemicals, namely plywood or core board and principally consist of the following forms:

a) Plywood,
b) Laminated wood,
c) Core boards,
d) Sandwich boards,
e) Fibre boards, and
f) Particle boards.

Plywood

Thin sheets of expensive and rare woods had been used as facings on less costly woods as far back as 1500 B.C. in Egypt, fixed with some kind of animal glue. Commercial production of plywood, however, started in the 1880's when the first factory for the purpose was erected in Russia. The term plywood applies to glued wood construction, built of veneers so that the grain of each veneer is at right angles to that of the adjacent veneer in the assembly. Plywood offers a major advantage of increased strength properties besides being available in much larger sizes than the original wood. It has the strength distributed in both the directions and there is little or no tendency to split. Waterproof plywood made with special glues is also available. Plywood can also be moulded to various shapes and will retain those shapes more or less indefinitely. The tendency to warp is eliminated, because for each ply there is an opposite similar and parallel ply.

The manufacture of plywood is economically advantageous, because of the various traits indicated above. The main processes involved in plywood manufacture are:

a) preparing the veneers, namely, faces, cross-bands and cores, for gluing;

b) drying of veneers;

c) mixing and spreading the glue or adhesive;

d) pressing the glued lay-up into a panel;

e) conditioning of the panels; and

f) trimming, sanding and storage.

Plywood is used for interior walls and partitions in shops, offices, houses, factories and as shuttering for construction of concrete walls. It is used a great deal in the construction of railway carriages and for certain aircraft parts, besides in sports goods and also for making trunks and other baggages, in radio, wireless and television cabinets in addition to tea-chests for export of tea on a large-scale.

As Henry Thomson describes, plywood was first introduced in India around 1905 when packing of tea for export started in tea-chests made of imported three-ply plywood. Uncertain shipments during the two world wars, led to the need for indigenous production of plywood. The first factory to manufacture tea-chest plywood was set up in Assam in 1918. Another factory came up in the same state in 1924.

The forties witnessed the commissioning of three larger units with modern equipment capable of manufacturing synthetic resin bonded plywood of different grades. The industry has since made rapid strides in both technology and techniques of manufacture. India now produces all grades of plywood comparable in quality to that in any other country.

The installed capacity and annual production of plywood in India during the years 1951 to 1979 is shown in Table 12.15.

However, the overall production of plywood in the country is grossly inadequate considering the size of our population. Consumption of plywood in India is among the lowest in the world, i.e. 0.4 cubic metre per 1,000 persons while the corresponding figures for Malaysia, Australia, and New Zealand are 8.0, 63.0 and 64.0 cubic metres, respectively.

As on Jan. 1, 1982, there were 51 plywood factories in India, each with plant and machinery valued at over Rs. 20 lakhs, borne on the rolls of the Directorate General of Technical Development, Government of India, referred to as units in the organised sector (Table 12.16).

Besides the above DGTD units, there are about 100 mills in the small scale sector, mainly producing tea-chest plywood with a total estimated capacity of 25 m metre^2 and with production in 1981 at 16 m metre^2.

As N.D. Tiwari, former Union Minister for Industrial Development, said sometime back:

"Industrial development involves the best use of resources. The changing pattern of wood raw-material supplies for forest industries necessitates an accelerated development of wood processing technologies. In this regard, wood-based panel industry has an important role to play, as use of panel products not only helps in the conservation of our scarce wood resource but is also more economical, reduces design time and provides sophisticated finish."

The World production of wood based panels increased from 39 m metre^3 in 1963 to 97 m metre^3 in 1973, and to 102 m metre^3 in 1980, the most spectacular increase being in the latest and most rapidly expanding sector—that of particle boards. India's share in this was only 0.24 m metre^3 in 1980.

Table 12.15: Production of plywood in India—m metre^2 (4 mm basis)

Sl. No.	Year	Installed capacity	Tea-chest	Commercial	Total
1.	1951	N.A.	5.6	0.9	6.5
2.	1955	N.A.	8.4	1.8	10.2
3.	1960	N.A.	9.1	6.0	15.1
4.	1961*	30.1	9.1	6.3	15.4
5.	1962*	34.5	9.8	7.8	17.6
6.	1963*	34.5	10.4	10.1	20.5
7.	1964*	34.4	9.7	10.6	20.3
8.	1965*	34.5	10.4	12.4	22.8
9.	1966*	36.6	9.7	12.7	22.4
10.	1967*	36.6	10.9	14.3	25.2
11.	1968*	36.6	11.6	16.8	28.4
12.	1969*	36.7	8.9	19.2	28.1
13.	1970*	36.7	4.3	18.4	22.7
14.	1971*	43.0	4.9	22.6	27.5
15.	1972*	43.0	3.6	28.3	31.9
16.	1973*	43.0	3.6	30.3	33.9
17.	1974*	43.0	3.3	32.3	35.6
18.	1975**	43.0	3.4	28.4	31.8
19.	1976**	54.3	2.3	32.8	35.1
20.	1977@	61.8	N.A.	N.A.	39.8
21.	1978@	67.7	N.A.	N.A.	44.2
22.	1979@	67.7	N.A.	N.A.	46.8

Source: *Mehta, P.V., *Plywood Industry in India*, 1974
**DGTD office records.
@Composite Wood Branch, FRI.

Note: Production since 1970 onwards relates to DGTD units only; Small Scale Units having investment in plant and equipments of less than Rs. 7.5 lakhs were transferred to the respective State Directorate of Industries.

Table 12.16: Statement showing the capacity and statewise distribution of bigger plywood factories

Name of State/Union Territory	Registered/licenced Capacity as on 1.1.82		Production 1981 m metre^2
	No. of units	Capacity m metre^2	
North-eastern Region			
Arunachal Pradesh	2	11.18	
Assam	20	45.56	
Meghalaya	1	2.00	
Nagaland	1	1.80	
	24	60.54	36.58
Southern Region			
Andhra Pradesh	1	1.50	
Karnataka	7	8.65	
Kerala	9	+9.54	
	17	19.69	10.74
A and N Islands	2	8.07	5.61
Others			
Madhya Pradesh	1	4.00	
Maharashtra	3	3.24	
Rajasthan	1	1.50	
Uttar Pradesh	1	0.56	
West Bengal	2	2.72	
	8	12.02	1.28
Total	51	100.32	54.21

The main problem facing the plywood industry is the shortage of ply logs. Shrinkage of forests all over the country and inadequate regeneration of the wanted species have created genuine problems in this direction.

To augment the availability of ply logs, it is imperative to use alternate timber species, use low or medium girth logs, reduce the size of the peeler core to the minimum possible, provide better storage facilities and impart prohylactic treatment to timber logs and also improve methods of production to minimise waste at each operation.

Besides these, massive afforestation and regeneration programmes are necessary to be adopted for ensuring sustained timber supply to the industry.

Glue is an important raw-material used in plywood manufacture. It is quite costly in India. The present cost of urea-formaldehyde and phenol-formaldehyde resins in India is about four times the cost in international market.

India possesses some prized species of wood like rosewood, Andaman Padauk and teak, etc., of world standard in quality and beauty of grain. In 1980, Government of India stopped all export of wood and timber in log and sawn form. Despite limited production, some export of plywood, including wood faced with veneer sheets has been built up, aggregating to Rs. 8 crores per annum in value during the year 1979.

Laminated wood

Laminated wood is a built-up product made of wood layers, all laid with their grains parallel and glued, or otherwise fastened together. It remains relatively constant in dimensions under normally dry conditions and can be produced in a thoroughly dry condition in a relatively short time. It offers advantage in size and shape compared to the natural woods. But it is relatively of high cost.

Fibre boards

Fibre board is a sheet of material made of fibre or other cellulosic material. The material is first de-fibrated or pulped and fibres are then constituted into a mat and consolidated by pressure, heat, etc. Fibre boards are mainly in densities ranging from 32 to 1,440 kg/metre^3. The higher density boards are called the hardboards while the lower density boards are called the wallboards or softboards. The manufacture of these is for the most part an adoptation of paper making processes. There are three plants at present in India, namely Anil Hardboards, Bombay; Western India Plywood, Balipatan; Kerala and Assam hardboard, Gauhati.

Particle board

Particle board is a board or sheet made up from fragments of wood chips, shavings, flanks or sawdust bonded with organic binders with the help of heat, pressure, catalysis, etc. They are often designated as building boards or wall boards. In India there are now six units in production with a total installed capacity of 24,000 tonnes year.

Match industry

The manufacture of matches started in India in 1922 before which matches were almost completely imported. The industry at present consists of three sectors, namely, the mechanised, the non-mechanised small-scale and non-mechanised cottage scale sectors. The mechanised sector, namely Western India Match Co. (Wimco Group), an Indo-Swedish venture has five factories located at Ambarnath (Maharashtra), Calcutta, Dhubri (Assam), Madras and Bareilly (Uttar Pradesh).

The non-mechanised sector other than cottage units had in all about 1,000 units in March, 1979, the majority of which are located in Sivakasi, Sattur, and Kovilpatti in the State of Tamil Nadu. In September, 1979, there were about 5,400 cottage units—about 65 per cent in Tamil Nadu, 18 per cent in Kerala, 7 per cent in Andhra Pradesh and the balance spread over other States. The production of matches in the various years has been as follows (Table 12.17):

Table 12.17: Production of matches from 1950-78

Year	Production in million match boxes (50 matches each)
1950-51	4,669
1955-56	5,944
1960-61	6,629
1973-74	9,892
1977-78	14,149

The percentage of production of matches in the mechanised sector which was 69.4 in 1953-54 declined to 44.2 in 1973-74 and 28.1 in 1977-78. The percentage of the small-scale sector was 62, while that of the cottage scale sector 9.9 in 1977-78.

Starting from the budget of 1979-80, a major advantage has been given to the cottage-scale sector by giving them a preference in excise duty for the reason that the cottage industry sector provides large-scale employment. The structure of excise duty on safety match industry in 1978-79 and 1979-80 is presented in Table 12.18.

Table 12.18: Excise duty imposed on safety match industry
(Rs. per gross boxes of 50 matches)

	1978-79	1979-80
Mechanised sector (WIMCO)	4.83	7.20
Non-mechanised sector other than cottage units (Small-scale Sector)	4.52	4.50
Cottage sector units (KVIC and Co-operatives)	3.36	1.60

In 1979, Government of India appointed a Committee headed by V.M. Dandekar which brought out its Report in January, 1980. The total employment in both non-mechanised, middle and cottage sectors put together was estimated at 1,13,000 in the year 1977-78. The Committee concluded that the revenue cost for creating additional employment was Rs. 20.5 crores (in terms of loss of excise revenue). In other words, the revenue cost of additional employment worked out to Rs. 2,102 per additional worker in the non-mechanised middle sector and Rs. 2,669 in the cottage sector. In 1980-81, Government of India collected an amount of Rs. 50.3 crores on account of excise duty on matches.

The match industry is facing a serious shortage of wood. For example, the Forest Department of Uttar Pradesh which used to supply large number of *semul* and *gutel* trees to the WIMCO unit in Bareilly in 1950's is unable to supply even 20 per cent of these now. WIMCO has set up a forestry extension division during the last five to six years which has promoted large-scale plantation of poplars specially in Uttar Pradesh, Punjab and Haryana. The division raises nurseries and distributes high quality saplings. A new company Wimco Seedlings Ltd. has been constituted with foreign collaboration in 1984.

Packaging industry

Packaging of various products is an important industry the world over. Among the packaging media, wood containers constitute the most conventional, and commonly adopted system. Apart from the FRI, Dehra Dun, the Indian Institute of Packaging, Bombay has been carrying on important investigations on packaging materials for various products. Recently, corrugated fibre board (CFB) boxes have come into use as a suitable substitute for wooden packaging for a variety of products. According to K.M. Tiwari, President of the FRIC (1983) the present annual turnover of the packaging industry in India is estimated at Rs. 1,300 crores, while goods worth Rs. 3,700 crores annually become unfit for consumption due to infrastructural deficiencies in the distribution system.

According to agricultural experts, India produces 64 per cent of the mangoes in the world, second largest quantity of banana after Brazil (10.6 per cent), etc. During the period April-December, 1982, India exported vegetables, mangoes, and other fruits valued at about Rs. 18.00 crores. All these require proper packaging and the potential is very large. Packing cases are important for apples. One cubic feet of timber can make two and a half cases of 20 kg capacity each, required for packing apples. Engineering goods require proper packaging for transit within the country, as also for export. According to Industry sources, the present (1983) requirements of wood, bamboo, and CFB for some of the main products are shown in Table 12.19.

A CFB carton equal in size to wood consumes 35 per cent of wood used for making a wooden box. A wooden packing case for 20 kg of apple, say in Himachal Pradesh at present costs Rs. 7 or Rs. 8 due to the subsidised cost at which wood is supplied, while a CFB case for the same costs Rs. 15 to Rs. 16 due to the excise amount involved in it. For economy of wood, it has been suggested that the duty on such boxes should be waived, or duty draw back allowed to the industry, through National Co-operative Agencies like NAFED or the State Co-operative Agencies like the Himachal Pradesh Marketing Cor-

Table 12.19: Requirement of wood, bamboo, plywood and cardboard for packaging of different products

Product	Capacity in tonnes			
	Wood	Bamboo	Plywood	CFB
1. Engineering goods (10% of packed substitutable)	1,50,000	—	—	25,000
2. Fresh vegetables/Fruits (5% of packed substitutable)	—	1,00,000	—	1,25,000
3. Tea (80% of packed substitutable)	—	—	60,000	40,000
4. Man-made fibres (100% of packed substitutable)	1,85,000	—	—	22,620
5. Cotton textiles (30% of centralised sector packed) and 5% of decentralised sector packed substitutable	10,700	—	—	13,050
6. Apples (100% of packed substitutable)	42,000	—	—	61,000
7. Tobacco (100% of export and 20% of domestic packed substitutable)	1,44,900	—	2,340	24,750
8. Mango (10% of packed substitutable)	1,93,800	17,000	—	85,000
Total	7,26,400	1,17,000	62,340	3,96,420

Source: Article by M.L. Mehra, in National Workshop Brochure on Packaging (1983).

poration. Packing cases from pine needles are proposed to be made. Requirement of wood for packaging are likely to grow at a fast rate, and intensive plantations of appropriate species/substitution/economy measures need to be evolved to meet the situation.

Other forest-based industries

Other industries based on forest products like oilseeds, essential oils, tans and dyes, katha and cutch, gums, drugs and pharmaceuticals and shellac have been mentioned earlier while considering production forestry, besides hosts of others. It would seem that forest based industries play a vital role in supplying essential products in the national economy and provide large scale employment.

CHAPTER 13

Forest Research and Education

Forest research

Research is an essential ingredient of carrying on any natural resource development. In the forestry sector in India, research is undertaken at the Forest Research Institute and Colleges, Dehra Dun along with its regional centres at Jabalpur, Bangalore, Burnihat and Coimbatore, as also by the respective State Forest Departments. The beginning of organised forestry research was made in India in 1906 with the establishment of the Forest Research Institute and Colleges at Dehra Dun. In the late 1920's the Forest Research Institute and Colleges moved into acquired lands on the outskirts of Dehra Dun, which facilitated expansion of research activities and taking up of experimental plantations. The work done at the FRI led, amongst others, to the compilation of yield and volume tables for important forest species, the preparation of a treatise on silviculture of Indian trees and on forest insects and pests, publication of statistical code and experimental manual for forestry research, work on the anatomy of Indian timbers, utilisation of forest products and more particularly use of bamboo as a pulping material.

The provinces (now States) concentrated on silvicultural research mainly in connection with regeneration work. Silviculturists were appointed in the United Provinces in 1918, Bengal and Madras in 1919, Bihar and Orissa in 1921, Central Provinces in 1922, Assam in 1927, Bombay in 1929 and Punjab in 1930. Since then all the States have created posts of silviculturists, in some States more than one, or Conservators of Forests, Research and Development, with several silviculturists under them.

Silvicultural Conferences used to be held quinquennially to discuss problems of forest research leading to co-operative research on important forest problems concerning various States. Since 1974, two separate Conferences are held at 5 years' interval, one on forestry and forest biology, and the other on forest products. While the FRI works practically on all aspects of forestry, forest biology and forest products, the Coimbatore centre is concerned with regional problems in entomology, mycology, silviculture and soil sciences, and the Bangalore centre with those in sandalwood spike disease, wood preservation, wood anatomy and chemistry of minor forest products. The Jabalpur and Burnihat centres work in the various forestry disciplines of the regions. The various State Forest Departments are engaged in field oriented research, specially in silviculture.

The FRI is one of the oldest organisations of its type in the world, and is an unique institution in so far as it combines research and education under the multifarious disciplines concerning forests and forest products in a single campus. In its long history, it has many outstanding achievements to its credit, and the Institute has guided and shaped the course of Indian forestry for almost 80 years. The FRI, Dehra Dun has also been recognised as the foremost centre for forestry research and training in South Asia.

However, during the last 30 years or so, forestry research in India has been unable to keep pace with the requirements of rapidly developing programmes of forest development. For example, the progress of forest research schemes during the Second and Third Five Year Plans was utterly inadequate. In the Second Plan, the outlay on forest research was Rs. 80 lakhs against which a sum of Rs. 32 lakhs only was utilised. During the Third Plan, originally a sum of Rs. 155 lakhs was provided for research and training schemes. This was cut down later and finally schemes for Rs. 37 lakhs were sanctioned, against which a sum of Rs. 17.4 lakhs only was utilised during the Third Five Year Plan period. During the period 1966-1969, again, a sum of Rs. 14 lakhs only was utilised. In the early 1970's, the FRI with its subsidiary centres spent only a sum of about Rs. 1 crore per annum on normal programmes of forest research. There has been some marginal improvement in programmes of forestry research in the late 1970s and early 1980s, with the expenditure on central plan schemes rising from Rs. 1.16 crore to Rs. 2.20 crores in 1982-83.

Unlike agricultural research, research in forest sciences is hardly carried out in the universities in India, and barring some marginal research at a few centres, hardly any university is conducting research bearing on forestry. Some beginning has been made in co-operation between the State Forest Departments and the agricultural universities. An Institute of Forest Management has been started at Bhopal in 1982 to devote special attention to various aspects of forest management, and is just taking tangible shape.

National Commission on Agriculture reports

In one of their interim reports as also in their final report, the NCA emphasised that immediate attention was needed to give a new orientation to forest research and education. The NCA felt that a particular responsibility of the Central Government should also be to carry out industrial research, which requires a large capital investment and special expertise and equipment. The Central Government along with universities should also co-ordinate and collaborate with research on utilisation, harvesting, economics, marketing, etc., of forest products in the States. Apart from the FRI, which should continue as a 'National Institute,' the Central Government should set up, where necessary, multidisciplinary regional research institutes and specific problem-oriented research centres.

The NCA felt that the State Forest Departments should confine themselves primarily to applied research on local problems in the field of forestry, forest biology and forest management, and if necessary establish research institutes for the purpose. The Commission felt that forest research would be enriched if the facilities and expertise available in the agricultural universities are utilised to cope with the research needs in the States.

Forest education

The FRI also looks after the forest education in the country. The first Forest Rangers College was established at Dehra Dun in 1878 when officers' training was done in Europe. The training of the Indian Forest Service Officers was commenced at the Indian Forest College, FRI and Colleges, Dehra Dun on 1st November, 1926, and was continued up to 1932. The training remained suspended between 1933 and 1938, as a consequence of which an acute demand for trained officers arose all over. In 1938, training re-commenced of superior forest services of the States to replace the Indian Forest Service in a two-year academic course. At present the FRI conducts one college for the Indian Forest Service Officers at Dehra Dun, three State Forest Service Colleges at Coimbatore, Burnihat and Dehra Dun, and three forest Rangers Colleges at Kurseong, Chandrapur and Balaghat; besides some States have also started their own Rangers Colleges to meet the heavy demand of Forest Rangers.

The NCA recommended that forestry science should be gradually introduced in the agricultural and other universities, which should undertake forest research. To begin with they should include forestry as one of the subjects in the undergraduate courses, the scope of forest education being gradually widened to graduate, masters and doctorate degree courses in forestry. The syllabus of forest education was recommended to be drawn up by a National Committee specially oriented for the purpose. The NCA strongly felt that the FRI should also organise graduate, master's and doctorate degree courses in forest science outside the in-service training and educational courses. They felt that elements of teaching and education should be integrated.

It may be mentioned that the Second Expert Committee Report under the Chairmanship of M.S. Thacker on the Working of the FRIC in their Report in 1966 had recommended that the FRI should be declared an institute of national importance. Although the Ministry of Agriculture had given an assurance to the Estimates Committee of the Parliament in 1968, that a decision would be taken in the matter within a period of six months, the position still remains where it was 16 years ago. The NCA in 1976 recommended that for direction and promotion of forest research and education, a Council of Forest Research and Education (CFRE) should be set up in the Union Ministry of Agriculture, with the Central Minister of Agriculture as its Chairman, and apart from Forest Officers there should be others, like the Director-General of Indian Council of Agricultural Research, the Director-General of Council of Scientific and Industrial Research, research scientists/teachers from universities/forest research organisations and also from outside the forestry discipline as members.

The NCA also recommended that the various disciplines of forest research and education should be grouped into the following three wings of the CFRE, each to be assisted by a Standing Committee: (a) forestry, forest biology, forest management and operations researches, (b) industrial and utilisation researches, and (c) education and training.

For identification of research problems, four Technical Committees were recommended to be set up by the CFRE for the four regions, namely, eastern, northern, western and southern. The research programmes were recommended to be finalised on the basis of the proposals formulated by the panels to be discussed at the regional conferences.

It is unfortunate that programmes of forestry research have not made a headway. Outlays on agricultural research under the Sixth Five Year Plan amount to more than Rs. 300 crores, while the amount under forestry research approved in the Sixth Plan is Rs. 12 crores which is also not likely to be spent in full. As a draft of the revised National Forest Policy, prepared by the Department of Environment, Government of India (1983) says "the extent to which forestry research has been hitherto neglected is reflected by the fact that while there are nearly 25,000 scientists engaged in agricultural research, the corresponding number engaged in the field of forestry is only a few hundred." Inadequate research programmes have seriously hindered the development of forestry development in the country.

Research programmes

The main objectives of research in forestry and forest biology should be to discover ways to improve production from all types of forest lands as far as possible, and to obtain maximum produce both from natural and man-made forests, consistent with the needs of environmental conservation. Research needs to be intensified on the introduction of fast growing species both indigenous and exotic and timber species as well as fuelwoods and fodder trees. Studies on the mineral and fertiliser requirement of forest species remain an important area of research, particularly in the matter of raising better nursery stock. The production of quality seeds and their storage should also receive attention. There is need for an identification of the studies required on forest influences, particularly with regard to the water requirement and its consumptive use, micro-climate of forests in both natural and artificial regeneration areas, etc.

An essential part of forestry research has to be complementary research on forest soils. Studies on forest soil vegetation survey, improvement of problem soils in various forest areas, soil-water-plant relationship and effect of interaction of different applications and practices on forest soil remain important areas of research in different classes of soil. A special forest soil problem would be that of latosols and lateritic soils vis-a-vis forest management practices. These soils are found over a large part of India, particularly in southern, south-western, eastern and north-eastern parts.

Forest genetics

Forest genetics is an important area of forest research. As early as 1930, H.G. Champion had demonstrated the importance of seed origin in forest plantations. A little later he showed that twisted grain in *chir* pine was inherited. He also did important work in establishing an all-India teak provenance test.

Various silvicultural conferences since 1949 have emphasised the importance and need of widespread application of genetics and initiating research in this field. In 1956 the Expert Committee appointed to examine the working of the FRIC recommended the formation of a Forest Genetics Section, and in 1960 a Forest Geneticist was in position at the FRI Simultaneously J.D. Matthews, an expert from FAO, under expanded technical assistance programme visited the country, and in 1961 his report was published, outlining the programme of work and the technology giving guidelines to the newly established Forest Genetics Section, and the work expected of the Silviculture Branch at the FRI and the State Silviculturists in this respect. It provided a basis to give a good start.

The Second Expert Committee Report on the FRI (1965) stated that the "Forest Genetics Section should work in the closest collaboration with the Silviculture Branch. Forest Genetics is essentially a forestry subject, being primarily a specialised aspect of silviculture. Its problems arise largely from silvicultural experience and its work will be, to a greater extent, dependent upon the assistance and co-operation of the State Silviculturists. At the present stage of development, most of the time of staff of the Genetics Branch should be spent in the field, and devoted to the selection of seed stands and plus trees, the collection of material and the organisation of seed orchards and progeny trials."

In countries like Sweden and U.S.A., major progress has been made in Forest Tree Breeding and genetics. In U.S.A. maximum effort has been put on the improvement mostly of pines and Douglas fir. Many seed orchards have already come into commercial production. Between 1965-70 it was reported that the Georgia Forestry Commission had been able to give planting stock of improved material at the rate of 23.4 m seedlings of *Pinus taeda* and 13.3 m seedlings of *P. elliottii* per year. In 1968 members of North Carolina State University-cum-Industry Co-operative produced 30 m improved pine seedlings, from seeds obtained from clonal seed orchards and their estimate for 1970 was 100 m seedlings of *P. attenuata* and *P. radiata*, for reforesting difficult sites and recreation of areas where fast growth is needed.

The establishment of seed orchards and seed production areas in the United States has been proceeding at a rapid rate. Estimates of total area required for individual species are revised frequently as more precise data on seed yields and plantable areas are gathered. The seed orchard areas by type ownership as on September 1, 1970 in the U.S.A. were as follows:

Type ownership	*Area in ha*
Industrial	1,330
State	960
Federal	610
Total	2,900

Among the most important species taken up for the purpose are *Pinus elliottii* (slash pine) and *Pinus taeda* (loblolli pine) for which seed orchards as of September 1, 1970 were established over 930 and 1,120 ha respectively. Other species taken up for the purpose were *Pinus echinata* or short-leaf pine, *Pinus palustiris* or long-leaf pine and *Pseudotsuga menziesii* or Douglas fir, etc. In addition, centres have been established at several southern nurseries to produce cuttings of *Populus deltoides* (eastern cottonwood) from genetically superior strains. Similar centres are also used to produce cuttings of hybrid poplars.

According to a report "Forestry in India" issued by the Forestry Division, Department of Agriculture and Co-operation, Ministry of Agriculture, 1982, 410 plus trees of *Tectona grandis*, 80 of *Pinus roxburghii* and 50 of *Bombax ceiba* have been selected in India. In addition to these, seed production areas of 32 species have also been selected in the different States of the country. Two lots of seeds have been harvested from the experimental clonal seed orchard of teak established at New Forest, Dehra Dun. About 50 per cent of the 800 grafts flowered to yield approximately one quintal of seed. These seeds from the orchard have shown about 50 per cent germination compared to the normally low germination of seeds collected from the forest. These seeds collected have been distributed for field trials in different States of the country. Two promising hybrids FRI-4 and FRI-5 have been evolved at the FRI by crossing *Eucalyptus tereticornis* and *E. camaldulensis*. These are being tried in different locations. On the whole, however, much more concerted efforts are necessary in the field of forest genetics than has been the case so far.

In the field of social forestry it is urgently necessary to find out suitable species for wind breaks and shelter belts, plantation techniques in degraded forests and wastelands, effect of different species in shelter belts and wind on crop fields and economics of growing various species. It is also necessary to find suitable undercrops and grasses for raising in the field plantations. Biological research is needed on various pests and diseases and their control as a priority programme, specially in view of the large scale programmes of man-made forests being undertaken.

Spike disease of sandal

Special mention deserves to be made of the spike disease on Sandal (*Santalum album*) which has eluded research workers so far. The disease was first reported in 1899 and has been progressively spreading throughout the whole southern part of Karnataka and adjoining areas of Tamil Nadu and Andhra Pradesh. Spike disease of sandal is a 'yellow type of disease' showing witches broom effect. The most characteristic symptoms of the disease are the severe reduction of internodes of affected branches, accompanied by suppression of the reproductive phase in spiked branches, including phyllody of flowers. The colour of the leaves also changes to yellowish and finally reddish before death. Ratio between length and breadth of the spiked leaves is almost double of that of healthy leaves. The diseased trees are killed within two to three years after infection. Till the early 1960's the spike disease was considered to be of viral origin, as no organism was found associated with it and it was experimentally transmissible by bud and patch graft.

Discovery in the late sixties that many yellow types of diseases are caused by mycoplasma like organism (MLO) led to the suspicion that the causal agent in sandal spikes may be MLO. At present the Bangalore centre of the FRI, in collaboration with the IARI is carrying on researches on sandal spike on the theory that the disease is caused by MLO. Electron microscopic examination is reported to reveal the presence of MLO's in the leaves of some of the affected plants. No solution has however yet been found to control the disease. Elimination of collateral hosts of diseased pathogen, control of insect vector/vectors, chemotherapeutic treatment of the diseased trees at the early stage of the disease, and removal of badly affected trees (to reduce the source of infection) have been suggested as available alternatives so far to minimise the losses. A strong concerted multi-disciplinary research programme is necessary to continue intensive research on the spike disease of sandal, in the absence of which an important national resource is seriously endangered.

Other items of research

Intensive research is also necessary on problems of industrial and utilisation aspects of forestry. Recently (1981) an Indian

Paper and Pulp Research Institute has been established at Dehra Dun. The plywood industries have a research institute of their own at Bangalore. Major research programmes are necessary in the field of forest economics and forest management.

Among the continuing research programmes at the FRIC, special mention may be made of the schemes of forest-soil-cum-vegetation survey, tropical pines research, environmental research to study the effect of vegetation on soils, and also co-relating atmospheric precipitation with vegetal cover and stream flow, research and demonstration in growing cash crops in newly felled forest areas in conjunction with forest species, Indo-Danish Project on Seed Procurement and Tree Improvement, high level conifers regeneration research, forest fire protection research, creation of radio isotope laboratory facilities, etc. A National Forest Computer Centre has also been established at the FRIC in 1983. The Sixth Five Year Plan document specially envisaged forest research projects on bamboo, *neem* and leguminous trees and shrubs. This was to cover (a) survey and exploration of major areas where *neem* and leguminous trees occur; (b) selection of suitable eco-types, and assembling the variation in germ plasm banks; (c) studies on vegetative propagation techniques; (d) breeding and improvement work, provenance and progeny trials; and (e) cytological and chemical studies.

Indian Council of Forest Research

However, not only the forestry research programmes from production-cum-environmental considerations remain inadequate, despite some outstanding individuals, whatever programmes/schemes are initiated, they often fail to take off sufficiently for lack of support personnel. Out of the 1,900 posts sanctioned in the Indian Forest Service, only 1,300 were filled in 1983, the short term deputations do not serve the purpose, as research is very often a matter of life-long dedication. In general, during the years 1978-84, not more than 50 per cent sanctioned research posts in the FRIC remained filled up. In July, 1983, the President, FRIC has submitted an ambitious research and education programme of Rs. 125 crores for a Five-Year Period, and the World Bank and the bilateral agencies have also shown a keen interest to help and partly finance such a programme, but the establishment of an autonomous Indian Council of Forest Research and Education with sufficient funds at its disposal, establishment of separate Institutes/Centres with specific objectives, and a separate Indian Forest Research and Education Service are *sine qua non* for any success in this direction.

Botanical and Zoological Surveys of India

Mention deserves to be made of the Botanical and Zoological Surveys of India, the activities of which are closely allied to forestry. The former was established in 1890 with the primary objective of surveying the plant resources of the country and has a number of achievements to its credit. Unfortunately the activities declined during the period 1937 to 1954 when even the post of the Superintendent of the National Botanical Gardens-cum-ex-officio Director of the Botanical Survey of India was kept in abeyance. With the reorganisation of the Survey in 1954, considerable work in intensive exploration of the plant wealth of the country has been taken up. This work is organised at present under seven Regional Circles. The Botanical Survey has carried out surveys of the plant wealth of the country over extensive areas.

The Zoological Survey of India created in 1916 at present carries out its activities under eight Regional Stations in different parts of the country. Their main objective is to carry out basic work of survey of the animal wealth in the country and research in systematics, zoo-geography, biology and animal ecology. The country has a rich fauna. The Zoological Survey of India has a rich collection represented by 8.5 lakh specimens of animal life.

Forest floras

The question of forest floras needs to be mentioned in some detail. The masterly work *Flora of British India*, started in 1872 was completed by Joseph Hooker with a team of 15 botanists in 1897. This was followed by the publication of Regional Floras, such as the *Flora of the Presidency of Bombay* by Cooke in 1901, *Flora Simlensis* by Collett in 1902, *Flora of the Plains of Bengal* by Prain in 1903, *Flora of the Upper Gangetic Plains* by

Duthie (1903-22), *Flora of Assam* by U.N. Kanjilal, Das, P.C. Kanjilal and De in 1934-39 (last volume on Gramineae by Bor in 1940), *Flora of Bihar and Orissa* by Haines in 1921 (supplement by Mooney in 1950) and the *Flora of South Indian Hill Stations* by Fyson in 1932.

Mention may also be made of the *Forest Flora of N.W. & C. India* by Steward and Brandis (1874), *Forest Trees of Travancore* by Bourdillon (1908), *Forest Flora of Bombay* by Talbot (1909), *Forest Flora of Punjab, Delhi and Hazara* by Parker (1918), *Forest Flora of Andamans* by Parkinson (1923), *Forest Flora of Kumaon* by Osmaston (1927), *Forest Flora of Chakrata, Dehra Dun and Saharanpur Forest Divisions* by U.N. Kanjilal, revised by Gupta (1928), *Forest Flora of Pilibhit, Oudh and Gorakhpur* by P.C. Kanjilal (1933), etc.

Among the forest floras brought out more recently are included a *Flora of Khandala in Maharashtra* by Santapau (1953, revised 1967), the monumental work on *Grasses of India, Pakistan, Burma and Ceylon* by N.L. Bor (1960), originally Forest Botanist at Dehra Dun and later working at the Kew Botanical Gardens, the revision of *Gymnospermae (conifers, cycads etc.) of India and adjacent countries* by Raizada and Sahni (1960), Maheshwari's *Flora of Delhi* (1963), P.C. Kanjilal's *Forest Flora of the Plains of U.P.* (1966), Gupta's *Flora of Nainital* (1968), Patel's *Forest Flora of Gujarat* (1971), and Raizada, Jain and Bhardwaja's completion of Duthie's unfinished *Flora of Upper Gangetic Plains* in two parts (1957-64).

In recent years also the Botanical Survey of India, Forest Research Institute and some private publishers have been reprinting valuable out-of-print floras such as those by Gamble, Cooke, Prains, Kanjilal, Brandis, etc. Earlier floras need urgently to be brought up-to-date. The Botanical Survey of India have recently launched a project entitled *Flora of India Project* in collaboration with the Forest Research Institute and some universities with a view to bring out a new flora of India.

CHAPTER 14

Investments in Forestry and Forest Policy

Forest working plans and national planning

Working plans have been made for many forests in India for more than 100 years now, and are revised every 10 or 15 years. National Planning in India started in 1951 with the advent of the First Five Year Plan for the country. The overall objects of planning are to make an assessment of the material, capital, human and other resources of the country, to augment such resources as are deficient in relation to the nation's requirements, and to formulate plans for the most effective and balanced utilisation of the country's resources.

The First and the Second Five Year Plans (1951-61)

During this decade, the focus of forest national planning was on the rehabilitation of the degraded private forests recently taken over by the Government, and the creation of plantations of economically important species suitable for matchwoods and other uses. During the Second Plan, stress was also laid on the conservation of wildlife, and several wildlife sanctuaries were established.

The Third Five Year Plan (1961-66)

The Third Plan laid special emphasis in forestry sector on measures to meet the long-term requirements of the country of wood and non-wood products, and to ensure more economic and efficient utilisation of forest products. The immediate objective was to increase the output from the existing forests through better techniques of timber extraction, improvement of communications, and popularising the use of less commonly known secondary Indian timbers, after proper seasoning and preservative treatment. As the various schemes implemented during the Third Five Year Plan period were oriented towards attaining self-sufficiency in industrial timbers, fuelwood and other forest products, large scale plantations of industrially valuable species were undertaken. In order to encourage State Governments to undertake plantations of quick growing species, particularly to meet the requirements of pulp and paper, a new Centrally sponsored scheme "Plantations of Quick Growing Species" was introduced.

Besides the above, a Pre-Investment Survey of forest resources was initiated during the Third Plan, in collaboration with the United Nations Special Fund and the Food and Agriculture Organisation of the United Nations. Improved logging tools were also prescribed to be used.

The annual plans (1966-69)

During the three annual plan years (1966-69), specific emphasis was laid on plantations of quick growing species and modernising harvesting and plantation techniques.

The Fourth Five Year Plan (1969-74)

The Fourth Five Year Plan laid down three main objectives, namely to increase the productivity of forests, to link up forest development with various forest based industries and to develop forests as a support to rural economy. It was stressed that one of the major problems of India's forests was their low productivity. Emphasis was laid on measures to meet the immediate and long-term agricultural and industrial requirement. It was envisaged to increase the supply by 1973-74 to 13.5 m metres^3 of industrial wood. The object was to achieve self-sufficiency in forest products as early as possible, especially for major forest-based industries, so that the imports of some of these items may be stopped and some sizeable exports of paper and wood panel products built up. The basic principle of Government policy that minor forests, pastures and grazing grounds must be managed in the interest of the population of the tract, and particularly to serve the local requirements of fuel and fodder was emphasised, and with this object, concerted action in this respect on part of the forest, revenue, agriculture and animal husbandry departments in co-operation with village panchayats and zila parishads was envisaged. Co-ordinated research programmes in forestry, continuance of pre-investment survey of forest resources, forest labour co-operative societies, conservation of wildlife especially in national parks and sanctuaries and preservation of the country's rich flora and fauna were emphasised.

The Fifth Five Year Plan (1974-79)

The primary objective in the Fifth Plan was to take up a dynamic programme of production forestry, aiming at creating large scale man-made forests with the help of institutional financing. The produce from felled areas was to be utilised in wood based industries by locating additional units wherever required. The second important objective was to develop farm forestry and to improve degraded forests so as to increase the fuel and timber supply in the rural areas. A system of meaningful forest surveys to assess the present growing stocks, increments and potential increments by forest divisions, natural regions and States, along with a proper information system was to be built up.

A network of State Forest Corporations was proposed to be created for the establishment and management of man-made forests and forest-based industries, in accordance with the recommendations of the National Commission of Agriculture in their Interim Report on Production Forestry—Man-made Forests. Project Planning approach was to be widely used, and special efforts were proposed to be made in the Plan period to prepare a number of projects in various States, indicating the immediate and long-term benefits in terms of increased raw materials for industries and additional revenues at different levels of investment.

The Sixth Five Year Plan (1980-85)

According to the Sixth Plan, forest policy has to fulfil three sets of needs: (a) ecological security; (b) fuel, fodder and other domestic needs of the population; and (c) the needs of village, small-scale and large-scale industries. In conformity with the objectives, the major area of thrust is on the promotion of a people's forestry movement. An important aspect, which was stated, required a closer attention in the coming years on employment generation through forestry activities.

The Sixth Plan also lays special emphasis on inter-dependence of tribal economy and forest development. The primary emphasis is on maintaining a proper environmental balance and the conservation of natural resources, specially on the conservation of gene resources. Revenue hunting is not the object, considering the vital value of forests for environmental conservation. Social forestry programmes comprising of (a) mixed plantations on waste-lands, and (b) reforestation of degraded forests and raising of shelter belts are envisaged. A new centrally sponsored scheme of social forestry including rural fuelwood plantations and farm forestry has been introduced in 100 selected districts. An important part of the strategy is to grow fuelwood as near as possible to the consumption points. Another object is that the entire contractor agency should be eliminated from forest working in all the States during the Sixth Plan period. The Pre-investment Survey of Forest Resources has been converted into a full-fledged Forest Survey of India. People's participation in forestry is to be the special aim, besides programmes for tree for every child, creation of an eco-development force specially for the West Himalayan Region and agro-forestry programmes.

Under the chapter of Environment, the Sixth Plan also says that the large-scale deforestation in recent decades has rendered the sensitive catchment areas in the Himalayas and other hills, particularly vulnerable to soil erosion. It goes on to say that no more than about 12 per cent of the country's land surface is actually under adequate tree cover, as against the target of 33 per cent prescribed by the National Forest Policy of 1952. It further adds that with disappearing species and ecosystems under the relentless pressures of an exploding population and unplanned development of our natural environments, the habitats of our species are being rapidly lost or modified. It says that at the present inadequate level of scientific knowledge in our country, we do not know how many species of flora and fauna are threatened, endangered or extinct, and lays very special emphasis on conservation of genetic resources and natural ecosystems. "The diversity of biological organisms is a vital resource, which needs to be carefully protected in natural ecosystems if we are not to close many possible evolutionary options for benefitting future generations." The plan also says that there is a compelling conservation need to set aside sufficient representative examples of biotic provenances to extend protection to entire community of species in viable terrestrial and marine ecosystems, to be designated as Biosphere Reserves.

Plan outlays

Under the various Five Year Plans, the total public sector outlays, the outlays under the forestry sector, and the percentage of forestry expenditure to the total public sector outlay is given in Table 14.1.

Table 14.1: Outlay in forestry section in Five Year Plans (Rs. in crores)

Plan/Period	Total Public Sector	Forestry Sector	Percentage of Col. (3) Over Col. (2)
(1)	(2)	(3)	(4)
First Plan (1951-56)	1,960	7.64	0.39
Second Plan (1956-61)	4,600	21.21	0.46
Third Plan (1961-66)	8,576	45.85	0.53
Post Third Plan (1966-69)	6,625	41.93	0.63
Fourth Plan (1969-74)	15,778	84.42	0.54
Fifth Plan (1974-79)	40,650	208.84	0.51
Annual Plan (1979-80)	12,550	68.33	0.54
Base Level of Total up to (1979-80)	90,739	483.22	0.53
Sixth Plan Outlay (1980-85)	97,500	692.49	0.71

It would be seen that the outlays in the forestry sector have been extremely inadequate, especially if the need for large-scale afforestation for environmental improvement is taken into account.

Plantation schemes

One of the important forestry programmes right from the First Five Year Plan through the Sixth Plan has been to raise plantations under Social Forestry and production forestry schemes. Table 14.2 summarises the physical and financial achievements from the First Five Plan to the year 1980-81 and the targets of the Sixth Five Year Plan for these schemes.

The table shows that up to the year 1980-81 an area of 1.6 m ha was planted up at a cost of Rs. 127 crores under Social Forestry schemes while a 2.2 m ha area was planted under production forestry programmes at a cost of Rs. 162 crores, making a total of 3.8 m ha at a total cost of Rs. 289 crores. The Sixth Plan targets for the combined social and production forestry plantations are for an area of 2.1 m ha at a total cost of Rs. 452 crores. Also tree plantation and afforestation is one of the important items in the 20 Point Programme of the Prime Minister.

The Sixth Plan document says that "Programmes of social forestry and economic and industrial plantations have been under implementation for some time in different states with varying degrees of effectiveness". Although valuable experience has been gained during the last 30 years, and schemes of plantations in different states and agro-climatic zones were modified from experience from time to time, critical all-India appraisals of these programmes are lacking. Perhaps overall success achieved in these programmes is not more than 35 per cent. Even this success has helped as an important factor of environmental improvement, as also to meet the spirally increasing demands of wood all over the country.

Besides the schemes of social and commercial plantations, the various five year plans have concentrated on schemes of rehabilitation of degraded forests, settlement and demarcation of erstwhile private forests (especially in the earlier plans), construction of roads, opening of hitherto inaccessible forests, improvement of logging methods and reduction of waste in conversion, construction of essential buildings in forest places, etc., which schemes had a wholly beneficial effect on forest management.

Table 14.2: Achievement of Five Year Plans (Physical: ha; Financial: Rs. in lakhs)

Plan/Period	Social Forestry		Production Forestry		Total Plantation	
	Physical	Financial	Physical	Financial	Physical	Financial
First Plan (1951-56)	15,130	16.42	36,957	111.91	52,087	128.33
Second Plan (1956-61)	1,47,222	1,99.33	163,948	486.88	3,11,170	686.21
Third Plan (1961-66)	2,60,315	543.05	323,054	1,569.64	5,83,369	2,112.69
Three Annual Plans (1966-69)	1,27,806	428.90	325,171	1,873.46	4,52,977	2,302.36
Fourth Plan (1969-74)	1,90,280	706.70	523,990	3,727.30	7,14,270	4,434.00
Fifth Plan (1974-79)	5,67,335	5,253.26	653,861	5,474.80	12,21,196	10,728.06
Annual Plan (1979-80)	1,21,877	2,195.41	101,301	1,354.59	2,23,178	3,550.00
Annual Plan (1980-81)	1,52,811	3,372.42	95,325	1,612.59	2,48,136	4,985.01
Total	15,82,776 or 1.6 m ha	12,715.49 or Rs. 127.15 crores	2,223,607 or 2.2 m ha	16,211.17 or Rs. 162.11 crores	38,06,383 or 3.8 m ha	28,926.66 or Rs. 289.26 crores
Target						
Annual Plan (1981-82)	2,89,424	6,520.61	1,26,296	1,971.44	4,15,720	8,492.05
Sixth Plan (1980-85)	15,23,870	35,188.35	6,24,042	10,031.24	21,47,912	45,219.59

Note: 1. Achievement figures for 1980-81 are provisional and subject to revision.

2. Figures given in the Statement do not include information for Forest Development Corporations.

Revenue from forests

As an important land use, and as a major natural resource, forests give certain levels of revenue. The average annual revenue, expenditure and surplus of Forest Departments of undivided India is given in Table 14.3.

Table 14.3: Average annual revenue and expenditure in ('000 rupees) **of forests departments in India (including FRI and Colleges)***

Average for the period	Gross revenue	Expenditure	Surplus	Surplus as percentage of gross revenue
1936-37 to 1938-39	2,58,68	1,94,37	64,31	24.9
1939-40 to 1941-42	3,27,46	2,09,00	1,18,46	36.2
1942-43 to 1944-45	8,30,18	4,92,00	3,38,18	40.7
1945-46 to 1947-48	14,92,81	6,76,81	7,86,00	53.7

*1961. *One Hundred Years of Indian Forestry, 1861-1961*, Vol. II.

Similar figures for India 1951-52 to 1980-81 are given in Table 14.4.

Table 14.4: Average annual expenditure (crores in rupees) **of forests in India (including FRI & Colleges) from 1951 to 1981**

Average for the period	Gross revenue	Expenditure plan and non-plan	Surplus
1951-52 to 1953-54	24.01	10.62	13.39
1955-56 to 1958-59	41.84	17.12	24.72
1961-62 to 1963-64	69-38	32.23	37.15
1966-67 to 1968-69	107.50	56.63	50.87
1969-70 to 1971-72	135.87	73.49	62.38
1980-81	472.55	317.83	154.73

Forest revenue, plan and non-plan expenditure and surplus or deficit by States and Union Territories for 1980-81 are given in Table 14.5.

Table 14.5: Financial working of forest departments (state-wise)—1980-81
(Rs. in lakhs)

S. No.	State/Union Territory	Revenue	Expenditure (Normal and) plan	Surplus (+) or Deficit (—)
1.	Andhra Pradesh	2,609.14	1,482.49	(+) 1,126.65
2.	Assam	1,124.55	635.80	(+) 489.25
3.	Bihar	1,471.13	726.48	(+) 744.65
4.	Gujarat	1,128.01	1,297.55	(—) 169.54
5.	Haryana	158.97	309.33	(—) 150.36
6.	Himachal Pradesh	1,615.85	1,306.45	(+) 309.40
7.	Jammu & Kashmir	1,878.07	1,336.33	(+) 541.74
8.	Karnataka	4,600.00	2,568.00	(+) 2,032.00
9.	Kerala	3,178.36	767.88	(+) 2,410.48
10.	Madhya Pradesh	1,3944.12	8,993.17	(+) 4,950.95
11.	Maharashtra	5,219.53	2,696.25	(+) 2,523.28
12.	Manipur	23.83	105.60	(—) 81.77
13.	Meghalaya	87.56	2.11	(+) 85.45
14.	Nagaland	50.12	254.55	(—) 204.43
15.	Orissa	2,520.67	856.13	(+) 1,664.54
16.	Punjab	404.40	529.16	(—) 124.76
17.	Rajasthan	651.34	1,502.51	(—) 851.17
18.	Sikkim	31.56	106.59	(—) 75.03
19.	Tamil Nadu	1,125.42	917.63	(+) 207.79
20.	Tripura	1,124.69	924.71	(+) 199.98
21.	Uttar Pradesh	2,030.00	2,333.18	(—) 303.18
22.	West Bengal	1,423.38	1,316.71	(+) 106,67
	Total States	46,400.70	30,968.11	(+)15,432.59
1.	A. & N. Islands	380.25	422.85	(—) 42.60
2.	Arunachal Pradesh	381.81	233.30	(+) 148.51
3.	Chandigarh	—	—	—
4.	Dadra & Nagar Haveli	22.59	17.33	(+) 5.26
5.	Delhi	0.53	0.15	(+) 0.38
6.	Goa, Daman and Diu	66.88	108.58	(—) 41.70
7.	Mizoram	2.84	32.46	(—) 29.62
8.	Pondicherry	—	—	—
	All India Total	47,255.60	31,782.78	(+) 15;472.82

Note: Figures Provisional.

Investments in forestry

Considering the environmental and production requirements from forests, it has been recognised throughout the last 25 years that investments in forestry programmes have continued to be very inadequate. The Central Board of Forestry in their various Resolutions from time to time have emphasised this, have suggested the need and importance of sustained and increasing investments in forestry and the creation of a Sinking Fund by investing a portion of revenue, etc.

Forest growing stocks

Of the 75 m ha of India's forests, according to the information issued by the Ministry of Agriculture, 46 m ha are exploited, and another 16 m ha are potentially exploitable. Without doubt extensive areas suffer from absence of regeneration or inadequate regeneration. The total growing stock is assessed at 2000 m metre^3. Assuming an average value of this at Rs. 200 per metre^3, the value of the total growing stock at current prices comes to Rs. 40,000 crores, besides the value of land. We thus have an enormous capital resource. As 95 per cent of India's forests are State-owned, it also needs to be recognised that besides vital and essential physical and environmental benefits and extensive facilities in the supply of forest produce to the people, the national forests are perhaps the most important public sector undertaking which should be managed also for the direct financial gains they are capable of yielding.

The present exploitation rate of industrial and fuelwood in Indian forests is about 32 m metre^3 annually, including 13.5 m metre^3 of industrial wood and 18.5 m metre^3 of fuelwood; or taking the exploited area of 46 m ha it is about 0.7 metre^3/ha/annum. In case of fully productive forests, comparatively of quick growing species, this rate of increment could be 10 metre^3/ha/annum and more; in cases of other species; it could be half or one-third of this quantity. While conditions in different types of forests and in different localities vary enormously, it is known that by far most of our forests are in a state of serious underproductivity. India's forests are at present yielding a surplus of about Rs. 155 crores in revenue or about Rs. 20 per hectare per annum averaging over the entire forest area which is also extremely small. The potential is easily 5-10 times this figure, despite the many difficulties of social and biotic factors.

Projections of demand of industrial wood and fuelwood given earlier and the steeply escalating prices of industrial wood and fuelwood at a much higher rate than the general rate of inflation indicate the serious scarcity of wood being already experienced, which will grow worse unless radical steps are taken to make much heavier investments for increased production and also for environmental improvement. The country is endowed with rich resources of plenty of sunlight and good rainfall and excellent soils in many areas. As such the forests also ought to play their full part in meeting the heavy adverse national balance of trade, amounting to about Rs. 5,800 crores in 1980-81 and Rs. 5,500 crores in 1981-82, the exports in the last year quoted being Rs. 7,700 crores, against an import of Rs. 13,200 crores.

Besides cutting out present substantial imports of products of forest based industries, there is also the great potential for export of forest products specially paper, wood panel products, gums and resins and medicinal products of plants, etc.

Inadequate investments

On account of inadequate investments, the position of forest resource development continues to be very unsatisfactory, as forests at present are neither supplying adequate or possible quantities of raw materials for industries, nor generating enough financial resources and employment they are capable of, besides greatly improving and building up the overall forest resources for the future. Unlike in agriculture, there has been no breakthrough in forestry sector. The facts that by far the bulk of the country's forests are situated in the most backward areas and the development of forest resources will also in most cases help in the development of such areas and tribal communities, are additional reasons for giving forestry sector a special priority in allocation of funds.

A basic fact of forestry sector needs to be appreciated. There is an essential difference in the development of a resource like forests and say, an irrigation-cum-power project or the setting up of a steel plant. For the latter, considerable initial investments are necessary before any development can be initiated. This is not altogether the case while considering the development of the existing forest resource. This is because the growing stock in any forest is a valuable and ready resource. The fellings from most of the forests, even from the poorer ones, yield revenue which is often considerably higher than the investment needed for planting it up; yet adequate resources for essential works like undertaking plantations, construction of roads, fire protection, etc., are not made available. Funds are often uncertain even to the limited extent that they are provided with the result that development programmes suffer seriously.

Leaving aside the limited practically bare areas in our forests, whenever we go to raise plantations in existing forest areas, the expenditure incurred in raising such plantations is quite often considerably less than the revenue to be derived from felling the forest under question. Even though our forests are in a serious state of under-productivity, the foresters will not and rightly so, agree to clear a forest area unless planting up can be assured, and most often funds are not available for planting up the area. As such, a state of inaction which is utterly unsatisfactory, continues indefinitely. Sometimes mature stands of trees are standing, putting on negligible or even negative increment, but these cannot be felled, as natural regeneration is not expected to come up and financial resources are lacking for taking up such areas for planting up.

Forest development corporations

To get over the problem of inadequate investments in forestry, the National Commission on Agriculture, after detailed and careful consideration recommended in 1972 the formation of Forest Development Corporations to attract institutional finances in forestry sector, on the basis of specific projects and their profitability. Schemes such as the scheme of construction of forest roads, introduction of mechanised methods of extraction to reduce wastage in conversion, creation of nurseries and plantations at Chachpur in Himachal Pradesh worked from 1965 onwards, the working of the Forest Development Board, Maharashtra started in 1969 under which 3,200 ha of poor forests in Chandrapur, Nagpur and Bhandara districts were being converted into rich plantations, etc. had already shown the way.

Accordingly, 14 Forest Development Corporations were added to the two already existing from 1974 onwards, which have taken up some plantation and forest enriching activity as shown in Table 14.6.

Unfortunately, the Forest Corporations of some of the States like Uttar Pradesh and Himachal Pradesh have only taken up departmental working or extraction so far. Though this is important, the other activity of taking up intensive forest plantations with the help of institutional finance is even more significant and deserves to be taken up. Besides, most forest corporations have not yet been able to attract institutional financing on a large scale from the erstwhile Agriculture Refinance Development Corporation (ARDC), now National Agricultural Bank for Rural Development (NABARD), as was envisaged. One of the controversial issues has been that the ARDC/NABARD have been of the opinion that most of the forestry projects are viable at 11 per cent rate of interest, while the Forest Corporations have been willing to give only a lesser rate of interest. It seems that the total amount drawn by all the Corporations from Banks/NABARD so far (1983) is less than Rs. 10 crores, while the Projects in pipeline do not exceed Rs. 20 crores. These are extremely meagre amounts than what was envisaged. Keeping in view the need of accelerating the plantation programmes for purposes of improved environment as well as increased production, the pending issues between the NABARD and the Forest Development Corporations should be quickly resolved, and help of much greater institutional finance taken for sound and viable forestry projects, for increased production and environmental amelioration.

National Forest Policy

In 1952, Government of India laid down a National Forest Policy, issued under the Ministry of Food and Agriculture, Department of Agriculture's Resolution No. 13-1/52-S, dated 12.5.1952. The policy was formulated on the basis of six paramount needs of the country, namely the following:

1) The need for evolving a system of balanced and complementary land use, under which each type of land is allotted to that form of use under which it would produce most and deteriorate least.

2) The need for checking:

Table 14.6: Achievement of forest development corporations

Sl. No.	Name of the Corporation	Date of establishment	Authorised capital (Rs. crores)	Plantations made up to 1979-80 (ha)		
				Industrial plantation	Plantation crops	Total
1.	Andhra Pradesh Forest Development Corporation Limited	16-6-1975	3.00	10,686	5,529 (cashew & other crops)	16,245
2.	Bihar State Forest Development Corporation Limited	10-2-1975	5.00	10,565	—	10,565
3.	Gujarat State Forest Development Corporation Limited	20-8-1976	2.00	—	No plantation activity	—
4.	Kerala State Forest Development Corporation Limited	24-1-1975	10.00	9,168	1,120 (cardamom & teak)	10,288
5.	Madhya Pradesh State Forest Development Corporation Limited	24-7-1975	20.00	7,968	—	7,968
6.	Forest Development Corporation of Meghalaya	30-1-1975	2.00	977	48 (citronella)	1,025
7.	Tripura Forest Development and Plantation Corporation Limited	26-3-1976	5.00	2,673 (rubber & bamboo)	21 (citronella)	2,694
8.	West Bengal Forest Development Corporation Limited	19-7-1974	10.00	5,770	—	5,770

9.	Himachal Pradesh State Forest Development Corporation Limited	25-3-1974	5.00	—	No plantation activity	—
10.	Karnataka Forest Plantation Corporation Limited	25-1-1971	2.00	23,200	509	23,709
11.	Forest Development Corporation Maharashtra Limited	16-2-1974	5.00	71,525	—	71,525
12.	Orissa Forest Development Corporation Limited	26-9-1962	2.00	—	1,391 (cashew)	1,391
13.	Tamil Nadu Plantation Corporation Limited	13-6-1976	2.00	19,866	1,734 (cashew)	21,600
14.	Uttar Pradesh Forest Corporation	Nov., 1974		—	No plantation activity	—
15.	Andaman and Nicobar Forest and Plantation Development Corporation Ltd.	21-1-1977	6.00	751	— (oilpalm and rubber)	751
16.	Arunachal Pradesh Forest Corporation Limited	31-3-1977	1.20	534	24	558.
	Total		80.20	1,63,683	10,376	1,74,059

a) denudation in mountainous regions, on which depends the perennial water supply of the river systems whose basins constitute the fertile core of the country;

b) the erosion progressing apace along the treeless banks of the great rivers leading to ravine formation and on vast stretches of undulating wastelands depriving the adjoining fields of their fertility; and

c) the invasion of sea-sands on coastal tracts and the shifting of sand dunes, more particularly in the Rajputana desert.

3) The need for establishing treelands, wherever possible for the amelioration of physical and climatic conditions promoting the general well being of the people.

4) The need for ensuring progressively increasing supplies of grazing, small wood for agricultural implements and in particular of firewood and to release the cattle dung for manure to step up food production.

5) The need for sustained and increasing supply of timber and other forest produce required for defence, communications and industry.

6) The need for the realisation of the maximum annual revenue in perpetuity, consistent with the fulfilment of the needs enumerated above.

With regard to the above functions, forests of India were to be classified as follows:

a) *Protection forests*, i.e. those forests which must be preserved or created for physical and climatic considerations.

b) *National forests*, i.e. those which have to be maintained and managed to meet the needs of defence, communications, industry and other general purposes of public importance.

c) *Village forests*, i.e. those which have to be maintained to provide firewood to release cowdung for manure, and to yield small timber for agricultural implements and other forest produce for local requirements and to provide grazing for cattle.

d) *Treelands*, i.e. those areas which though outside the scope of the ordinary forest management are essential for the amelioration of the physical conditions of the country.

It was stated that the classification was merely illustrative and was by no means mutually exclusive. In fact every forest performs more than one function and therefore has to be so managed as to achieve the highest efficiency in respect of the chief functions assigned to it. However, a broad national classification was necessary to focus attention on the kind and object of management necessary in each case. It was stated that every sizeable forest, whatever its composition, location or category serves both the protective and productive purpose. It was stated that two considerations, plausible though at first sight, should be combated.

a) Neighbouring areas are entitled to a prior claim over a forest and its produce; and

b) agricultural requirement has a preferential claim over forest lands.

Village communities in the neighbourhood of a forest will naturally make greater use of the products for the satisfaction of domestic and agricultural needs. Such use should, however, in no event be permitted at the cost of national interests. The Policy Statement said that, the Himalayan forests, for instance, are the greatest of national assets; to them we owe the richness of the country. The denudation and under-development of the Himalayan slopes leads to greater intensity and frequency of floods, recurrent erosion and to coarse detritus being deposited on the fertile tracts in the plains. This process inflicts immeasurable loss and misery on the unsuspecting millions in the Indo-Gangetic Plain and brings about a progressive and permanent impairment of soil fertility and a cumulative reduction in the agricultural potential of the whole land. While, therefore, the needs of the local population must be met to a reasonable extent, the national interests should not be sacrificed because they are not directly discernible, nor should the rights and interests of future generations be subordinated to the improvidence of the present generation. Further, the notion that is widely entertained that forestry as such has no intrinsic right to land but may be permitted on sufferance on residual land not required for any other purpose has to be combated. The role of forests in the national economy, both protective, and productive, entitles forests to lay claims to an adequate share of the land.

PROTECTION FORESTS

The policy stated that the protection forests denote forests found, or required, on hill slopes, river banks, sea-shores or other erodable localities. In such sites, the need for forest cover is dictated by purely protective physical considerations, such as prevention of erosion, conservation of moisture, and control of rushing torrents and floods. The role of such forests in saving the soil from being washed away, and when maintained in catchment areas, in the prevention of floods and maintenance of streamflow, cannot be over-emphasised. On flat country with loose sandy soil, especially under dry conditions, forests, whether natural or artificial perform an essential function in minimising wind erosion, fixing the soil and preventing the formation of sand dunes, and mitigating the desiccation of agricultural crops, leeward of the tree cover. The National Forest Policy, therefore, required an immediate and speedy programme for the reconditioning of the mountainous regions, river valleys, and coastal lands by establishing protective forest over large areas, and preserving the existing ones. The primary object of management of such forests should be to utilise in full their protective influence on the soil, the water regime, and the physical and climatic factors of the locality; and the interests to be thus protected should far outweigh those which it may be necessary to restrict. The scientific management of such "protection forest", wherever possible, should include the production and exploitation of timber within the limits of safety.

The policy aimed at the reconditioning of hills and dales, particularly to combat the progressive denudation with serious repercussions on the fertility of land and the growing erosion along the banks of rivers of which the Yamuna, the Chambal, the Mahi, the Narmada, the Kosi and the Damodar were cited as notorious examples. The immobilisation of the Rajasthan desert was emphasised.

NATIONAL FORESTS

The policy said that the national forests constituted the basis of India's strength and wealth, for they comprise valuable timber bearing regions, the produce of which was indispensable for defence, communications and vital industries. So, their management on scientific and business lines was essential for maintaining a sustained supply of wood to attain national self-sufficiency in these vital supplies. Cultivation was not to be permitted, to encroach upon these valuable timber bearing tracts. The solution of the food problem of an ever increasing population was to be sought primarily in intensive cultivation, and not in weakening the very basis of national existence by encroaching upon such forests.

VILLAGE FORESTS

Village forests were to serve the needs of the surrounding villages in respect of small timber for housing and agricultural implements, firewood, leaves for manure and fodder, fencing thorns, grazing and edible forest products. The supply of such requirements was to be made at non-competitive rates provided they were utilised for bonafide requirements of the people, but not for trade. The management of such village forests was to aim at meeting the present as well as the future needs of the people. However, removal of the produce in excess of the annual growth was not to be permitted. It was stated that these considerations render the entrusting of the management of village forests, to panchayats, without appropriate safeguards, a hazardous undertaking as had been demonstrated in some of the States earlier. However, the co-operation of panchayats was to be enlisted in the protection and creation of village forests and in the distribution of forest produce.

TREELANDS

The policy statement iterated that the extension of treelands in due course was ultimately intended, towards which a concerted and supreme effort on the part of various departments and Government agencies was to be made. Under this item the duty of the Forest Departments concerned was laid down as follows:

1) To awaken the interest of the authorities within their region in the development, extension and establishment of treelands.

2) To draw up plans for such purposes bearing in mind the need for species of commercial importance.

3) To establish nurseries and seed stores in each area for the supply of saplings, plants and seeds.

4) To supervise the planting of trees and render such technical assistance as may be necessary for the development of treelands.

5) To arouse tree consciousness among the people by publicity, by celebrating the *Vana Mahotsava*, and by encouraging *Vana Premi Sangh*.

A campaign inducing villagers to plant trees in village commons and along roadsides on the condition that they would enjoy the benefits of the fruits, timber and other produce of trees planted by them was recommended.

PROPORTION OF FOREST AREAS

The proportion of land to be kept permanently under forests was to naturally vary in different regions. The policy stated that practical considerations suggested that India as a whole, should aim at maintaining one-third of its total land area under forests. As an insurance against denudation, a much larger percentage of the land, about 60 per cent was to be kept under forests for their protective functions in the Himalayas, the Deccan and other mountainous tracts liable to erosion. In the plains, where the ground was flat and erosion was normally not a serious factor, the proportion to be attained should be placed at 20 per cent and in view of the pressure of agriculture, effort at the extension of treelands should be concentrated on river banks and other convenient places not suitable for agriculture. At the same time it was to be realised that even distribution of forests in all physical regions was as important as its overall proportion. In certain localities deficient in forest, therefore, afforestation of marginal lands, and eroded river and village waste lands was suggested to be undertaken. Forest area in excess of the indicated proportion, if any, was however not to be sacrificed. To maintain an overall average, it was essential that States better suited for the growth of trees should help to make good the deficiency in those parts where climatic and edaphic factors militated against tree growth.

WILDLIFE

The policy emphasised the need for affording protection to the animal kingdom and particularly to rare species. Bird and animal lives were to be controlled by special laws, and rare fauna preserved by setting up sanctuaries and large-scale national parks.

GRAZING

The formation of the grazing policy was to be based on the following cardinal principles:

a) Continuous grazing on the same areas by large herds is destructive of the better strains of grasses and leads to a deterioration of the grass complex. Wherever it is permitted and is in great demand efforts should be made to introduce rotational grazing, the benefits of which should be explained and demonstrated to the villagers.

b) Cheap forest grazing has a demoralising effect and leads to the vicious spiral of reckless increase in the number of cattle, inadequate forest grazing, reduced quality of the herds, and further increase in the numbers to offset the fall in quality. Free and indiscriminate forest grazing is, therefore, a serious disservice to cattle breeding. The notion that a farmer's wealth must be reckoned in terms of the number of cattle he owns, regardless of quality, is one of the causes of India's uneconomic cattle wealth and must be combated.

c) Grazing should not be looked upon primarily as a source of revenue. But the simple and obvious way of regulating and controlling grazing as also improving the quality both of grazing and cattle themselves, is to institute a reasonable fee for the privilege of grazing.

d) Grazing must not be allowed in regeneration areas and young plantations during such periods as the seedlings require for establishment, otherwise they stand in danger of being browsed or trampled upon.

e) Grazing incidence should be kept at a minimum in "protection forests".

Restrictions on sheep grazing in forests and total exclusion of goats was recommended. The creation of special fodder reserves under strict rotational control was indicated. It was suggested that the tribals should gradually be weaned away from the practice of shifting cultivation by persuasion and a missionary approach.

SUSTAINED YIELDS

The policy of sustained yields was emphasised. It was stated that the compilation of all sound working plans requires the following:

a) The calculation of increment so that what is annually put is annually cut, leaving the original assets intact or improved.

b) The preparation of maps and investigations on the propagation and tending of various species, their increment, the optimum conditions of their growth and the regulation of yield.

c) Carefully planned afforestation schemes to replace inferior tree growth by valuable species of commercial importance.

Each State was, therefore, recommended to set up a permanent organisation to deal with working plans—their compilation and revision and deviation from them, research and statistics as well as to conduct detailed surveys of available forest resources which are a *sine qua non* for sound forest management.

Necessary steps for forest legislation, forest education, training of field staff, services, forest research, liaison with industry, etc., were indicated. The great importance of the welfare and goodwill of the people in the neighbourhood of forests was specially emphasised and it was stated that no forest policy, however well intentioned and meticulously drawn up, has the slightest chance of success without the willing support and cooperation of the people. The recognition of their rights to forest produce at concessional rates, or free of royalty, is not by itself enough. What is necessary is to instil in the people a direct interest in the utilisation of forests. Necessity of providing sufficient budgetary grants for forest development and the creation of a sinking fund were recommended.

The policy statement said that while the discretion of State Governments to regulate the details of forest administration in their respective territories was left unfettered, the general principles of the above forest policy were in paramount national interests to be observed by them in framing their policies and legislation for the conservation of their forest resources. The forest policy of every State was to be so framed as not to impinge adversely upon the general economy and physical balance of an adjoining State. It was to be in consonance with the general principles underlying the forest policy laid down by the Centre for the preservation and development of the nation's forest resources which were so vital to its general well-being.

Policy implementation

It would seem that the National Forest Policy as laid down in

1952, is, on the whole, an excellent document. Apart from the then I.G. Forests, M.D. Chaturvedi, the credit for laying down such a clear cut policy, defining the relative priorities as well, also goes to the genius of Vishnu Sahay, then Secretary Agriculture, Government of India, besides of course the keenness of the great Prime Minister, Jawaharlal Nehru for clear thinking in what was going to be an important national public sector activity in the country. However, in practice implementation of this policy generally was poor. There was not sufficient action, often inaction or sometimes action in the reverse gear. While the extensive private forests taken over by the Government were settled and consolidated and working plans made definite progress, the *Vana Mahotsava* idea usually got reduced to occasional ceremonial tree planting, and flopped. Practically no efforts at all were made towards extensive Himalayan afforestation, which was strongly recommended and was urgently needed. Under the relentless pressure of an expanding human and bovine population, forests often regressed, or retrograded in many places, with serious adverse effects on environment. It may be mentioned that the Forest Policy statement of 1952 does not use the word 'environment,' as this word in its present connotation came into vogue the world over only towards the end of nineteen sixties, but the words "amelioration of physical and climatic conditions", soil and water conservation, perennial water supplies of rivers, etc., which is what environment largely connotes in relation to forests today received due and proper emphasis in the 1952 policy statement. It is also mentioned sometime that the forest policy mainly aims at earning revenue from forests. This is incorrect. Among the six major objectives laid down at the beginning of the statement "realisation of the maximum annual revenue in perpetuity" comes last, and that only "consistent with the fulfilment" of the earlier five requirements, viz., environmental improvement, supplies of forest produce to villagers and for other national requirements.

Forest policy revision

The Estimates Committee (1968-69) of the fourth Lok Sabha in its seventy-sixth report suggested a re-appraisal of the 1952 forest policy in the light of the experience gained in the intervening period. In particular, it suggested the following:

1) Effective steps should be taken by the Central Board of Forestry to increase the forest area in the various States.

2) Proportion of the area that ought to be under forests in each State/Union Territory should be clearly indicated.

3) The Central Government should accord priority to the detailed survey of all lands as a basis for evolving a system of balanced and complementary land-use.

4) Necessary steps should be taken, to demarcate forests on functional basis and to collect statistics thereof.

5) The Government should take effective measures to ensure that simultaneous steps are taken to afforest suitable areas equal to those which have to be deforested on account of the implementation of development projects.

6) The feasibility of regulation/restricting rights of local inhabitants under customary laws in certain States by providing suitable assistance to the affected parties may be examined by the Central Board of Forestry.

7) There is need to provide adequate funds on a continuous basis to achieve the desired results in the development of forests, etc.

Since then the Central Forestry Commission, the Central Board of Forestry and the Indian Board of Wildlife have constantly considered the matter over the course of years. The National Commission on Agriculture also considered the matter in detail and gave their views on the subject. In the meantime it became clear that under the prevailing circumstances, various States were by themselves unable to deal with the situation. Consequently under the 42nd amendment in the Constitution of India (1976), Forests and Wildlife were included in the Concurrent List. On 22 Oct., 1980, the Government of India issued the Forest Conservation Ordinance, which became an Act in December, 1980, under which all deforestations require prior approval of the Government of India. The National Committee on Environmental Planning and the newly formed Department of Environment in the Government of India also gave their earnest and detailed consideration to the matter. A new draft of the National Policy was considered by the Central Board of Forestry in their meeting in August, 1982. The Department of Environment have also brought out their recommendations on the subject in April, 1983. Besides phraseology, there are on the whole comparatively small differences in the two latest drafts and the 1952 policy statement. For example on the question of grazing, the Draft Policy Statement by the Department of Environment says the following:

The ultimate aim of our policy for the management of livestock should be to completely switch over to a system of stall-feeding of genetically improved and much more productive animals. While moving towards this objective, it is necessary to regulate the entry of the cattle in forest areas in accordance with their carrying capacity. This may be done through measures such as the following:

1) Total prohibition of grazing by all animals in young plantations, regeneration areas and special conservation areas.

2) Total prohibition of grazing by camels and goats in all forest areas.

3) Total prohibition of scrub and other unremunerative cattle in all forest areas.

4) Progressive increase in grazing fees till they reach deterrent levels.

A question of considerable importance, on which there is a difference of opinion is that of felling a forest and planting it up. The policy draft of the Department of Environment expresses the following view on the subject:

During recent years, many natural forests have been clear-felled and replaced by monocultural plantations of quick growing species—usually exotic—by various State Forest Departments and State Forest Development Corporations. This has led to the loss of much biological diversity and also to certain other ecologically harmful results. It is necessary to ensure that clear-felling is not undertaken under any circumstances and that the choice of species for afforestation is made only after a very careful consideration of all available ecologically and economically suitable species. Exotic species should not be utilised for afforestation without adequate trials regarding their suitability and monocultural plantations should be generally avoided.

The Forestry Division draft of the Agriculture Ministry observes as follows in the matter:

In reforesting State-owned forest areas, after a programmed harvest or for enrichment of existing crop, due regard has to be paid not only to most productive crops for industrial and domestic use but also to safeguarding the ecological harmony. Man-made forests employing mono-culture practices must be interspersed with sizeable blocks of well-stocked natural forests for preserving habitats of flora and fauna.

The subject had received the attention of the National Commission on Agriculture also, who observed that "in production forestry clear-felling would have to be resorted on quite an extensive scale". In a U.S. Study by Lull. Haward W. and Reinhert Kenneth G. (1972), it had been found that infiltration is reduced by forest cutting only to the extent that forest soil is disturbed and compacted. No appreciable surface flow was observed other than from extraction roads. Continued high infiltration rates after clearfelling, with virtual absence of surface flow, have also been observed on experimental watersheds at the Coweeta Hydrologic Laboratory. Clearfelling without serious disturbance of the forest floor does not materially reduce infiltration rates. Provided only a small proportion of the watershed is felled at any one time, increases in peak flow and flood run-off will not be large enough to be important. In general the conclusions of the study with which the N.C.A. also agreed are the following:

a) The forest is the best of all possible natural covers for reducing peak flow and erosion.

b) With reasonable care, the forest can be cut with little detriment to its site-protective capability.

c) Under sustained yield programme of forest management and with the great diversity in age classes, the extent of forest cutting offers no flood threat.

d) The flood reduction role of the forest can be realised through continued fire protection and careful logging, and can be enhanced by reforestation of abandoned land.

The matter needs further close attention; apart from limited 'protection' areas, where no fellings are feasible, there should be no difficulty in combining the productive and environmental roles of forests, depending upon the objectives and the situation.

The 1952 Forest Policy Statement, and the two latest drafts by the Forestry Division of the Agriculture Ministry, and the Department of Environment deserve to be widely circulated to arrive at an agreed Forest Policy for effective implementation in the country.

CHAPTER 15

Epilogue

Environment and production from forests

Writing about 1952, M.D. Chaturvedi, the then Inspector-General of Forests for India wrote:

"The future of India hangs not in the political but in the physical balance. Our future is tied up with the maintenance of the equilibrium of the inexorable forces of nature which brooks no interference. The shape of things to come a couple of hundred years hence will depend upon how we conserve our soil, how we organise our physical defences against nature and how, in short, we protect our forests."

Chaturvedi was right, but not in the time span. Things have moved much faster during the last 32 years, and it is not a question of "a couple of hundred years hence" now, but the next two to three decades which are vital. Forestry has come a long way in India during the last 120 years, but has very very far to go, if it is to make its due contribution to environmental and economic development on the national scene. The forest area under the government control nearly doubled during the period from 1947 to 1953; this in itself was a major gain, because in private hands most of the forests would have disappeared as the situation was in the fifties. The recorded production of industrial wood increased five times from 1949-50 to 1979-80, and of recorded fuelwood to slightly less than twice. However, much of the fuelwood going out of the forests is not recorded. According to K.D. Singh, who has served many years in the Pre-Investment Survey of Forest Resources in India, and is now a senior officer in the Forest Division of the

FAO at Rome, almost 70 per cent of the well managed tropical forests of the world are in India.

As Erik Eckholm points out:

"As countries develop, wood remains a basic raw material for construction and also takes such useful forms as furniture, railroad ties, power poles, cellophane, rayon and plastics. Transformed into paper, it serves as an essential tool for government, commerce, education, and communications. In the years to come, wood may also provide liquid fuels and a wide array of petrochemical substitutes. For urbanites, forests provide natural havens of inestimable value to mental health, while trees both in and out of cities help create a more pleasant and comfortable milieu.

Forests perform irreplaceable ecological services as well as provide economic products and recreation. They assist in the global cycling of water, oxygen, carbon, and nitrogen. They lend stability to hydrological systems, reducing the severity of floods and permitting the recharging of springs, streams, and underground waters. Trees keep soil from washing off mountainsides and sand from blowing off deserts; they keep sediment out of rivers and reservoirs and, properly placed, help hold topsoil on agricultural fields. Forests house millions of plant and animal species that will disappear if the woodlands are destroyed."

Deforestations

But in India, there have been serious setbacks in forest management also. According to Shankar Ranganathan, a professionally trained forester turned industrialist, who has been writing brilliantly on ecology, forestry and agro-forestry during the last 10 years, India lost over 40 m ha of forested land during the last one hundred years, but more so from the start of World War II. Says Ranganathan, stripped of forest cover, such lands have been cultivated for a few years and then abandoned, because the land could not sustain agriculture, and now such lands are rapidly turning into desert and in the process ruining good agricultural land. According to official figures, India lost over 4 m ha of forests between 1941 and 1976 for agriculture and other purposes, but there seems little doubt that Ranganathan's estimate is more on the correct side.

Extent of tree cover in forest areas

There is some doubt also about the state of tree cover in the 75 m ha of land, officially classed as forest at present. India's Sixth Five Year Plan document says that less than half of this has actually adequate tree cover and 20 m ha of forest land is affected by erosion, while not more than about 12 per cent of the country's land surface is actually under adequate tree cover. Even some senior foresters are talking about this but no state-wise break-up of these figures is available. However, according to the publication *India's Forests*, 1980, issued by the Forestry Division of the Ministry of Agriculture, 45 m ha of forest area is 'exploitable', while another 16 m ha are 'potentially exploitable' adding up to 61 m ha. State-wise break-up of these figures is available. Now forests should have sufficient density, if they are 'exploitable' or 'potentially exploitable'. The position in this regard needs to be clarified on the basis of concrete information.

Poverty and increasing population

Gunnar Myrdal in *Asian Drama: an Inquiry into the Poverty of Nations*, 1968 writes:

"The simple truth is that India badly needs to make rapid progress in the whole vast countryside by changing all undesirable conditions. Concentrating on certain aspects of development now or in a few districts and settling for slow progress are both inadequate answers for a very undeveloped country whose labour force is now increasing by probably 2.5 per cent per year and must stay in agriculture, if it is not to swell the city slums and shanty towns."

The number of people below the poverty line is estimated at 50 per cent of the population or nearly 360 m, equal to the population of India just after the partition. As Shankar Ranganathan rightly points out:

"Population control is India's greatest need. Next to it is the quick provision of work for the enormous number of unemployed and underemployed to save them from starvation. With employment and a better life, population control may have a better chance of succeeding. Meaningful employment for the numbers involved, about 80 m currently, with an addition of more than 7 m every year, cannot be provided by industry. Agriculture which employs six times as many people as are employed in all other activities put together has a surplus of one in five who are flooding the towns and cities."

Further, the employment should be sustainable and productive and not subsidised, or in any case least subsidised. Now intensive forestry and tree plantation activity for improvement of environment and much higher levels of production than hitherto offers a major opportunity for providing millions of jobs in our rural areas. Agro-forestry and multiple use of land should be adopted on a much bigger scale than hitherto. Headloaders of firewood and migratory graziers should be allotted revenue and other lands and permanently settled in raising fuel and fodder trees, grasses and other produce.

To quote the late E.F. Schumacher (author of *Small is Beautiful*) from his foreword to *Forest Farming* by J. Sholto Douglas and Robert A de J Hart:

"As a 'fuel economist', I should like to say this: Since fossil fuels, the mainstay of the 'modern system', have ceased to be cheap and may soon cease to be plentiful, many people are becoming interested in solar energy. They are looking for all sorts of wonderful man-made contrivances to collect solar energy. I am not sure that they always appreciate the fact that a most marvellous, three-dimensional, incredibly efficient contrivance already exists, more wonderful than anything man can make—the tree. Agriculture collects solar energy two-dimensionally; but silviculture collects it three-dimensionally. This, surely, is the 'wave of the future'."

Forest statistics

As discussed in Chapter 7, figures of forest growing stocks and increments for most of our forests are very inadequate, and sometimes contradictory. If one visits any of the German, Swiss or Swedish forests, almost the first thing the visitor is told is the total forest area being visited, the forest growing stock, the volume increment being put on in the forests and the quantity of fellings annually being made by main species, which are most vital. Unfortunately, 'increment' figures are least available in most of India's Working Plans, even in the more sophisticated ones. These important statistics should be set in order by the State Working Plan Organisations, the Central Working Plan

Cell, and the Forest Survey of India in a time bound programme.

Re-orientation of working plans

A National Seminar on Forest and Environment, held at Bangalore in December, 1981, and attended by almost 150 senior Forest Officers from the Centre and the States, administrators, environmentalists, representatives of Agricultural Universities, non-governmental organisations and others adopted the following Resolution on Forest Working Plans:

"Clear-felling and over-felling of our forests have been taking place on a much larger scale than permissible from the ecological point of view due to a variety of causes and there is need for providing for safeguards against such possibility in the Working Plan. But the Working Plans hitherto were mainly oriented towards meeting specific demands already in existence with reference to increment, growth statistics and financial returns and no stress was laid on the aspect of orienting the working of the forest as a part of the total eco-system."

The Seminar therefore resolved:

"That the method of preparing Working Plans should be re-oriented to ensure preservation of the eco-system and to remedy the imbalances, if any and the existing Working Plan code may be suitably amended for the purpose."

The above. indeed shows a grim situation. All places where over-felling has taken place should be carefully identified at the earliest, and felling and plantation programmes adjusted to ensure preservation of the ecosystem. Needless to emphasise that as explained in detail in the earlier chapters, the production potential, consistent with environmental conservation over extensive areas of our forests is many times more than the present increment/production. This is specially so if as also recommended by the above Seminar, our plantation techniques are "suitably updated to include the use of adequate inputs like fertilisers, intensive soil working by way of mechanised ploughing", and provision is made for proper infrastructure of staff, etc.

Public and private sector in forestry

It is necessary to mention that forestry in India, unlike agriculture, suffers from the evils of a public sector undertaking. The fact that India is able to feed its very big population today, almost from indigenous production, is due to the motivation, self-interest, continuous hard work and initiative of millions of our cultivator families, besides of course the great efforts of the Government, agricultural scientists, and irrigation and power engineers. Madhav Gadgil and his associates carried out a study in Bangalore, Kolar and Tumkur districts of Karnataka, and found that the farmer is at least ten times more efficient in raising trees than the government. A similar picture emerged in Tamil Nadu and other States. The private forest farmers of Gujarat are also showing how much greater inputs and closer attention can give vastly superior results compared to those of the government professional foresters.

Regarding the participation by the industries in the production of raw material, the above referred to Bangalore Seminar recommended the following:

1) That the forest based industries should be actually associated in the raising of raw material for their industry as a joint venture with the Government wherein industry should contribute sufficient finance for the raising of plantations of suitable species, the produce of which will be reserved for their use to the extent of their contribution.

2) That it should be made legally obligatory on part of the industry to produce more than minimum prescribed out turn expressed as a percentage of the quantity of raw material used by employing modern equipment and qualified personnel.

3) That prices of the raw material may be fixed on the basis of cost of production taking the precaution to have prior consultation between neighbouring States where conditions are alike so that the prices, so fixed by them may be comparable.

Wastelands of India

The draft National Forest Policy of India drawn up by the Department of Environment, Government of India (April, 1983) aims at "establishing forests and pasture on all degraded and denuded lands whether these are classified as forest lands, or non-forest lands and which amount to *at least* (underline ours) 88 m ha", well within the year 2000. This indeed is a laudable object and fully worth attempting. But the difficulties in the way of such an objective are serious. The Sixth Five Year Plan document of India does not do justice to the question of land use and wastelands in India. It does say that "land is the primary resource on which agriculture is based", and states five main elements of land reforms policy, viz.,

1) abolition of intermediary tenures;
2) tenancy reforms;
3) ceiling on landholdings and distribution of surplus land;
4) consolidation of holdings; and
5) compilation and up-dating of land records.

But what about the extensive revenue, common or panchayat and forest wastelands. Should their condition be allowed to worsen, as is happening at present, or should positive policy steps be adopted and effectively implemented to reclaim them for environmental improvement, increased production and providing gainful employment to millions of our people, whether to landless along with sufficient inputs being placed at their disposal and others who have the skill, capacity and financial resources even partly, to be supplemented by banks, etc., to turn these wasting resources into productive assets in a time bound programme. The unequivocal answer seems to be to adopt the latter course. The Seventh, Eighth and Ninth Five Year Plans of India should adopt, say targets of reclaiming 20, 25 and 30 m ha of waste and degraded lands, and all necessary steps planned and taken by the Government of India, State Governments, research institutions, non-governmental organisations like the Society for Promotion of Wastelands Development, Association of Sarva Sewa Farms and hosts of others from now onwards. On Jan., 4, 1985, the Prime Minister of India Rajiv Gandhi, announced the proposal to set up a national wastelands development board, with the object of bringing five m ha of land every year under fuelwood and fodder plantations. A people's movement for afforestation is to be developed. These are indeed laudable projects, and need to be meticulously planned and executed.

Integrated programmes

This brings us naturally to the question of cost of such programmes. World Bank and bilateral agencies may contribute part of such costs, but the efforts should be essentially Indian, including costs. The costs per hectare may amount to Rs. 1,000 to Rs. 10,000 or more per hectare, depending upon the local conditions, technology adopted, and the intensity of operations required. Costs are likely to be higher and results poorer, if programmes are implemented by the Government, and vice-versa if programmes are undertaken by individuals and private organisations. Integrated soil and water conservation, afforestation and animal husbandry programmes can reduce the costs enormously, and greatly increase the chances of success. "Social fencing" as discussed earlier is a great positive factor in such programmes. Here we may quote the example of Bhartiya Agro Industries Foundation led by its eminent Director Mani Bhai Desai, who has reclaimed about 97 ha of wastelands at Uruli Kanchan near Pune in Maharashtra over the last 10 years. *Subabul* and fodders have been grown successfully for stall feeding over 600 excellent high bred cattle; the dung from the cattle goes to a *gobar* gas plant, and the slurry from the plant goes back to the fields, where fodders are grown. Water has been tamed at a number of places, and is properly utilised. We thus have not only an environmentally sound but an economic project running efficiently. Another small example; The Delhi Land and Finance Corporation has taken about 120 ha of seriously eroding land in Gurgaon district, Haryana, and are planning to develop it by putting up check dams, possibly a small lake, some terracing, road construction, etc., and are converting the place into a number of one hectare farms for sale and profit. Such experiments deserve to be replicated for different types of wastelands in hundreds and thousands of places for landless poor, if major afforestation and land development targets are to be successfully achieved.

Women and school children's programmes

For successful afforestation and land development programmes, close association of women and school children is of tremendous importance, because it is women who suffer most from problems like serious fuelwood, and fodder shortage. The experience of *Chipko* in Chamoli district of Uttar Pradesh led by Sunder Lal Bahuguna and Chandi Prasad Bhatt, where women played a major role is of great interest to people all over the country.

Land, water, forests and air

Anil Agarwal and his associates of the Centre for Science and Environment have brought out an excellent publication on *The State of India's Environment, A Citizen's Report, 1982.* The book vividly describes the soil and water conservation, afforestation and connected problems of India, which deserve careful study by all our people. But all that they say is not quite in conformity with facts. Sample the following for example:

"More insidious than hunting, however, was the destruction of forests wrought by the British because of the great demand for railway sleepers, wood charcoal, ships and so on. To get this wood, the British took over, without compensation, vast tracts of communally-owned forests throughout the country—an act of robbery surpassed only by the usurping of entire continents like North America and Australia by white settlers."

Now even during King Ashoka's reign, much of the India's forests were controlled by the State. During the later Hindu and Muslim period, much of our forests were apparently controlled by petty chieftains or were no man's lands. The British created a set of intermediaries in the lands, which was harmful to the national interests. Without a sound forest policy at home in the United Kingdom, however, the British organised large forests areas in India and settled them for scientific management, duly recognising the rights of individuals and communities where they existed. No doubt the British extracted sleepers to lay down rail tracks for the Indian Railways, but the same Railways gave India a unity, which it rarely possessed before, except for brief spells. In any case the forests of India today are *par excellence* a people's estate managed by the people's representatives for the nation. There could be no greater vindication for the British Forest Policy in India than the fact that one of the greatest and most powerful Chief Ministers of Uttar Pradesh, Govind Ballabh Pant who had himself fought the British on forest policy matters, made practically no change in that policy when he was Chief Minister for a long period for 18 years or so, and later became Home Minister of the Government of India.

Forest policies

The Bangalore Symposium on Forest and Environment (1981) referred to above adopted the following as one of their Resolutions:

"Mindful of the numerous references in this Seminar to the enduring importance of the biotic heritage for a wide range of human needs; conscious of the fact that the interests of the nation and the global community demand the preservation and protection of the remnants of the forests and the natural environment for sustenance and betterment of human life; also taking note that the day-to-day pressures on these natural endowments are relentlessly on the increase, this Seminar appeals to the Union Government and the State Governments to take steps to evolve a national consensus, accepted by all leading political parties, to place above party politics the national forest and environment policies, and their practical consequences concerned with the physical defences of the country, viz., air, soil, water, and the flora and fauna".

It would be excellent indeed if such a consensus could be evolved, and all efforts should be made to do so, though it may not be easy. In the latter case, no doubt the party in power, whether at the Centre or in the States, must do its duty, and be judged accordingly. The nation is indeed grateful to the late Prime Minister Indira Gandhi for her keen, active and positive interest in the conservation and development of forests for environmental and productive purposes, and as an important national heritage, and natural resource of the country.

It is however a sad reflection that forests are often made a pawn in the political game. The Centre for Science and Environment publication mentioned above, referring to some Chota Nagpur forests in Bihar quotes A.K. Roy, an M.P. from the area as saying "Sal has become a symbol of Jharkhand, and *Sagwan* (teak) a symbol of Bihar". During the years 1980-82, it is distressing to record that the tribals of Singhbhum cut down 22,000 ha of some of the finest sal (*Shorea robusta*), forests in the area, and even burnt the coppice that came from the shoots of these trees, besides, partly damaging 30,000 ha or so of other sal forests. The Forest Department somehow salvaged timber worth about Rs. 5 crores, but that cannot be a source of satisfaction. Incidentally these were/are the forests where ecologically, sal (occurring to the extent of 80 per cent or more—natural monoculture) is the happiest, and natural regeneration has/had been obtained, with no difficulty whatsoever during the last 50-60 years by adopting proper practices. Obviously, the political leaders, having inflamed the passions, were/are unable to control it. And if in cities and towns, people burn buses and vehicles, in forest areas, the local people just destroy forests, their own major source of livelihood and environmental conservation.

More than a year back, 'Wildlife' was separated from the Forestry Division of the Ministry of Agriculture and clubbed with the Department of Environment. Forests and wildlife are inseparable, and each is an integral part of the other. Placing of 'Forests and Wildlife' in the 'concurrent list' of the Indian Constitution put a special responsibility on the Government of India, which the Centre cannot ignore. In January 1985, a full department of Forest and Wildlife has been created for effective management of this important resource, under a separate ministry of 'Environment and Forestry', which is a proper step in this direction.

Review of rights and concessions

In 1981, the Government of India in the Ministry of Agriculture appointed a Committee to review the existing rights, concessions, tenures and settlements in the forest areas of the country for the sake of their rationalisation and effective management, with an able and experienced administrator, former Chief Secretary of Madhya Pradesh, M.S. Chaudhary, as its chairman, and a noted environmentalist N.D. Jayal, and three forest officers with rich experience in forestry as its members. The Committee toured intensively for two years in many States and held discussions with large number of people, including beneficiaries and village leaders. They issued their Report in March 1984, the epilogue of which reads as follows:

"The entry of millions of people to collect headloads from forests, of tens of millions of cattle grazing all over in many parts, of right holders for cutting timber trees suitable for their agricultural implements or house construction and under the general cover of right holders and concessionists, of various other elements of our society, deeply involved in extracting whatever benefits they can, has brought forest management, in very large parts of the country, to a stand-still. In fact, the conditions are so anarchical in many parts that new plantations disappear overnight. Large tracts are devastated within short spells and the continuous march of degraded areas is unchecked. The Watch and Ward officials of the Department are either overwhelmed by the situation and the forces behind this exploitation or fall an easy prey to the temptations to make hay while the sun shines. The senior officers involved in management often become helpless and even when they act, they are hampered by political pressures. Ultimately, many of them are resigning to become mere watchers to the destruction. The Committee feels that unless this picture is radically altered no amount of social forestry or plantations will help increase the biomass production, whether for right and privilege holders or for the nation. The dwindling forests will disappear faster than is realised. Restoration of discipline, therefore, is a must and the sooner it is done, the better for our survival."

Forest consciousness

The above indeed is a very grim picture. Despite this, may it be hoped that the facts and suggestions given above and an adequate consciousness about the value of forests in our people will create an urge all over the country for the conservation and development of forests for environmental and economic purposes, and will thus also help in bringing about a major land use transformation in India, and provide new jobs to millions of our people.

Annexure 1: Area of man-made forests up to 1968-69 in North Eastern Region and Andamans ('000 ha)

Sl. No.	State/Union Territory	Total	Teak	Eucalyptus	Soft-woods	Conifers	Other species	Remarks
1.	West Bengal	83.1	8.0	8.9	4.0	2.3	60.00	*1
2.	Assam	46.00	6.0	—		0.5	39.5	*2
3.	Manipur	1.3	—	—	—	—	1.3	Break-up not clear
4.	Nagaland	1.8	—	1.8	—	—	—	
5.	Tripura	23.4	3.2	1.6	—	—	18.6	*3
6.	Arunachal Pradesh	5.0	—	—	—	—	5.0	Break-up not clear
7.	Andamans	6.4	5.4	—	—	—	1.0	*4
	Total	167.0	22.6	12.2	4.0	2.8	125.4	

*1. For West Bengal break-up by end-uses up to 1964 is indicated as follows:

Total	Construction woods	Teak	Matchwood/ Plywoods	Furniture woods	Pulp wood	Box wood and Misc.
41.4	14.4	4.0	3.5	6.2	4.7	8.7

*2. Main spp. are *Terminalia myriocarpa* (*Hollock*), *Chikrasia tabularis* (*Bigopoma*), *Michelia champaca* (*Titosopa*) and *Anthocephalus kadamba* etc.

*3. Main sp. are Sal, *gamar*, *garjan*, bamboo, *semal*, cashew.

*4 . Matchwood, *padauk*, rosewood etc.

Annexure 2: **Area of man-made forests up to 1968-69 in Western and Central Region ('000 ha)**

Sl. No.	State/UT	Total	Teak	Eucalyptus	Bamboos	*Khair*	Cashew	Other spp.	*Casuarina*	Remarks
1.	**Maharashtra**	133.8	24.2	52.7 includes some bamboo	9.3	0.4	6.8	40.4	—	
2.	**M.P.**	55.3	34.0	20.7	—	—	—	0.6	—	
3.	**Gujarat**	28.3	7.7	11.8	—	4.8	—	—	4.0	
4.	**Rajasthan**	22.4	Break up not available					22.4		
	Total	239.8	65.9	85.2	9.3	5.2	6.8	65.4	4.0	

Annexure 3: Area of man-made forests up to 1968-69 Southern and South Eastern Region ('000 ha)

Sl. No.	Name of State	Total	Teak	Eucalyptus	Wattles	*Casuarina*	Softwoods	Bamboo	Sandal	Cashew	Rubber	Fuel woods	Misc.
1.	Kerala	93.9	51.2	19.9	0.4	—	15.2	0.3	0.3	6.4	—	—	0.2
2.	Tamil Nadu	104.0	7.2	30.0	22.0	4.4	1.6	—	0.7	29.0	2.1	—	7.0
3.	Mysore	260.0	77.9	40.4	—		14.0	—		15.0	3.0	73.5	35.3
												Linaloe	0.7
												Cocoa	0.2
4.	Andhra Pradesh	92.8	18.2	9.4	—	10.9	0.4	6.5	0.8	14.0	—		31.7
												Coffee	0.4
												Red sanders	0.5
5.	Orissa	92.7	22.6	14.8	—	10.0	6.0	6.0	—	1.0	—	4.3	28.0
												Khair	
6.	Goa	9.4	2.8	4.4	—	—	—	0.6	—	1.6	—	—	—
	Total	652.8	179.9	118.9	22.4	25.3	37.2	13.4	1.8	67.0	5.1	77.8	104.0

Annexure 4: Area of man-made forests created in '000 ha up to 1968-69 in the Northern Region

Sl. No.	State	Teak	Sal	Eucalyptus	Bamboo	Softwoods	*Khair*	*Sissoo*	*Babul*	Misc.	Conifers	Total
1.	Bihar	7.1	—	11.5	22.2	1.7	—	18.2	—	15.2	—	75.9
2.	U.P.	10.0	20.0	34.3	25.0	30.0	20.0	26.0	30.0	125.0 or mixed	included under misc.	311.9
3.	Punjab	—	—	10.0	—	—	—	4.0	4.0	2.7	—	20.7
4.	Haryana	—	—	0.9	—	—	0.8	3.5	3.0	1.7	—	9.9
5.	Himachal Pradesh	—	—	14.0	—	—	10.0	1.5	—	10.5	24.0	60.0
6.	Jammu & Kashmir	Not available										
	Total	17.1	20.0	67.7	47.2	31.7	30.8	53.2	37.0	155.1	24.0	477.8

Bibliography

Agarwala, V.P., 1947, *Forestry in Relation to Land Management in India*, Report presented to the Imperial (Now Commonwealth) Forestry Institute, Oxford (Unpublished).

Agarwala, V.P., Seckler, D.W. and Tejwani, K.G., *Energy from Trees: The Second Green Revolution in India*, October 1981, Revised January, 1982 (Unpublished); Ford Foundation, New Delhi.

Agarwala, V.P., 1972, *Planning and Financing for Man-Made Forests in India*, Paper presented at the Symposium on Man-Made Forests in India, organised by the Society of Indian Foresters, Dehra Dun.

Agarwala, V.P., 1972, *Planning for Forests & Forest Products Industries in India (1973-79)*, Paper sent to the Seventh World Forestry Congress.

Agarwala, V.P., 1982, *Forest Raw Materials for Paper and Pulp Industry in India*, Paper presented at the Seminar on Raw Materials for the Paper Industry, by the Indian Paper Makers Association, New Delhi.

Agarwala, V.P., 1983, *Agro-forestry and Wastelands in India*, Paper presented at the National Workshop on Agro-forestry, Karnal, India.

Aggarwal, Y.K., 1981, Paper Industry in India, *Financial Express*, dated 2.2.1981.

Anonymous, 1981, *Annual Report*, Forest Research Institute & Colleges, Dehra Dun.

Anonymous, 1980, *Bamboo Research in Asia, Proceedings of a Workshop*, held in Singapore by the International Development Research Centre and the I.U.F.R.O., May, 1980.

Anonymous, 1980, *Basic Statistics of N.E. Region*, Government of India, N.E. Council Secretariat, Shillong.

Anonymous, 1978, *Country Report*, India, Eighth World Forestry Congress, Forestry Division, Department of Agriculture, Government of India, New Delhi.

Anonymous, 1977, *Desertification and Its Control*, Indian Council of Agricultural Research, Government of India, New Delhi.

Anonymous, 1981, *Development of Forestry and Forest Products*, Country Profile, India, Forestry Division, Ministry of Agriculture, Department of Agriculture and Cooperation, Government of India, New Delhi.

Anonymous, 1978, *Forestry for Local Community Development*, F.A.O. Forestry Paper.

Anonymous, *Hundred Years of Indian Forestry*, Volumes I & II, 1861-1961, Forest Research Institute & Colleges, Dehra Dun.

Anonymous, 1982, *Indian Agriculture in Brief*, 19th edition, Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, New Delhi.

Anonymous, 1972, *Indian Forest Utilisation*, Volumes I & II, Compiled and written at the Editorial Board, Forest Research Institute and Colleges, Dehra Dun.

Anonymous, 1980, *India's Forests*, Government of India, Department of Agriculture, Forestry Division.

Anonymous, 1981, (Compiled by Seth, S.K.), *India and Sri Lanka Agro-forestry: Forestry for Community Development Programme*, F.A.O., Rome.

Anonymous, *Indian Forest Statistics, Annual Publication for Various Years, 1938-39 to 1970-71*, Department of Statistics, Ministry of Agriculture, Government of India, New Delhi.

Anonymous, 1981, *Inventory Design and Resources Appraisal of Indian Forests*, Forest Survey of India, Eastern Zone, Ministry of Agriculture, Department of Agriculture and Co-operation, Government of India.

Anonymous, 1972, *Interim Report on Production Forestry—Man-made Forests*, National Commission on Agriculture, Government of India, Ministry of Agriculture.

Anonymous, 1977, *Leucaena, Promising Forage and Tree Crop for the Tropics*, National Academy of Sciences, Washington, D.C.

Anonymous, 1978, *Proceedings of the National Seminar on Resources Development and Environment in the Himalayan Region*, Department of Science & Technology, Government of India.

Anonymous, 1981, *Proceedings of the National Seminar on Forest and Environment*, Sponsored by the Karnataka Forest Department, Bangalore.

Anonymous, 1983, *Proceedings of the National Workshop on Substituting Forest Timber for Packaging*, Federation of Corrugated Box Manufacturers of India, 214, Mittal Estate No. 3, Vasanji Road, Bombay.

Anonymous, 1972, *Report of the Task Force on Forest Resources Survey*, Planning Commission, Government of India (Unpublished).

Anonymous, 1976, *Report of the National Commission on Agriculture*, Part V, *Resource Development and* Part IX, *Forestry*.

Anonymous, 1980, *Report Rashtriya Barh Ayog* (National Commission on Floods), Volumes 1 & 2, Government of India, Ministry of Energy and Irrigation, Department of Irrigation, New Delhi.

Anonymous, 1982, *Report of the Fuelwood Study Committee*, Planning Commission, Government of India, New Delhi.

Anonymous, 1984, *Report of the Committee on Rights and Concessions in Forests*, Ministry of Agriculture and Cooperation, Government of India, New Delhi.

Anonymous, 1974, *Seeds of Woody Plants in the United States*, Handbook No. 450, Forest Service, U.S. Department of Agriculture.

Anonymous, *Sixth Five Year Plan, India, 1980-85, and Earlier Five Year Plan Documents for India*, Planning Commission, Government of India, New Delhi.

Anonymous, 1982, *Soil Conservation, Problem, Approach and Progress in India*, Ministry of Agriculture, Department of Agriculture, Soil and Water Conservation Division, New Delhi.

Anonymous, 1982, *Desertification and Soil Policy, Symposia Papers III*, 12th International Congress of Soil Sciences, New Delhi.

Anonymous, 1971, *Technical Papers*, Seminar on the Role of Pine Resin in the Economic and Industrial Development of India, New Delhi.

Anonymous, *The Status of the Asian Elephant in the Indian Sub-Continent*, by the Asian Elephant Specialist Group of the Species Survival Commission of the International Union for Conservation of Nature and Natural Resources, Bombay Natural History Society, Bombay

Anonymous, 1971, *Souvenir on Minor Forest Produce*, November, 1971, Tamil Nadu Forest Department, Ooty.

Anonymous, 1982, *The State of India's Environment, A Citizen's Report*, Centre for Science and Environment, 807, Vishal Bhawan, 95 Nehru Place, New Delhi.

Anonymous, 1979, *Tropical Legumes: Resources for the Future*, National Academy of Sciences, Washington, D.C.

Anonymous, 1970, *Wildlife Conservation in India*, Report of the Expert Committee, Indian Board for Wildlife, Ministry of Agriculture, New Delhi.

Anonymous, 1964, *Centenary Commemoration Volume*, Forest Directorate, Government of West Bengal.

Anonymous, 1981, *Forest Resources of Tropical Asia*, Tropical Forest Resources Assessment Project, F.A.O.

Anonymous, 1979, *Eucalyptus for Planting*, F.A.O.

Anonymous, 1980, *Firewood Crops, Shrub and Tree Species for Energy Production*, National Academy of Sciences, Washington, D.C.

Anonymous, 1974, *Interim Report on Desert Development*, National Commission on Agriculture, Government of India, Ministry of Agriculture, New Delhi.

Anonymous, 1982, *Forestry in India*, Brochure, Published by Forestry Division, Department of Agriculture and Co-operation, Ministry of Agriculture, Government of India, New Delhi.

Anonymous, 1982, *India, A Reference Annual*, Ministry of Information and Broadcasting, Government of India, New Delhi.

Benskin, E., 1921, *Afforestation in United Provinces.*

Bhaduri, T. and Surin, V. 1981, *Community Forestry and Women 'Head Loaders'* (Unpublished).

Bhatt, Chandi Prasad, 1980, *Eco-system of the Central Himalayas and*

Chipko Movement: Determination of Hill People to Save Their Forests.

Claude Alvares, 1982, Article "*Social Forestry, The Likely Distortions*", Bio Energy Renews, Vol. 1, No. 1, India House Developments, New Delhi.

Bhumbla, D.R., 1983, *Fuelwood Plantations*, Paper presented at the seminar on "Cooking Energy" organised by Centre for Science & Environment.

Champion, H.G., 1938, *Progress of Forestry in India during the Past 35 Years*, Published by The Indian Science Congress Association.

Champion, Harry G. and Seth, S.K., 1968, *A Revised Survey of the Forest Types of India*, Manager of Publications, Delhi.

Champion, Harry G. and Seth, S.K., 1968, *General Silviculture for India*, Manager of Publications, Delhi.

Chaturvedi, A.N., 1983, *Eucalyptus for Farming*, U.P. Forest Bulletin, No. 48.

Chaturvedi, A.N., 1982, *Poplar Farming in U.P. (India)*, U.P. Forest Bulletin No. 45, Revised.

Chaturvedi, M.D., 1946, *Land Management in United Provinces.*

Childe, G., *What Happened in History* (Pelican Books).

Chaudhri, A.B., 1981, *Forest Resources of North-East India, A Realistic Assessment*, Pre-Investment Survey of Forest Resources, Dehra Dun.

Chowdhry, Kamla, 1983, *Forestry Development: Strategy & Structure*, Paper presented at the FAO/S.I.D.A. Consultation on Forest Administration for Development, Rome.

Dandekar, V.M., *The Cattle Economy of India.*

Divisional Forest Officer, 1981, C.A.D. Project, Gwalior. *Ravine Controls through Silva-ways—Pilot Project Report on Aerial Seedling in Chambal Ravine Areas of Madhya Pradesh.*

Douglas, J. Sholts and Robert A. de J., *Forest Farming.*

Dwivedi, A.P., 1980, *Forestry in India*, Jugul Kishore & Co., Dehra Dun.

Eckholm, Eric, 1979, *Planting for the Future: Forestry for Human Needs*, Worldwatch Paper 26 by the Worldwatch Institute.

Gadgil, Madhav, *et al.*, 1982, *Some Aspects of Forestry in India.* Centre for Monitoring Indian Economy, Bombay.

Gleisinger, E., *Coming Age of Wood.*

Glover, Sir Harold, 1944, *Soil Erosion*, Oxford Pamphlet on Indian Affairs.

Glover, Sir Harold, 1944, *Erosion in the Punjab, Its Causes and Cure.*

Goorie, R.M., 1941, *Land Management in Punjab Foothills.*

Gorrie, R.M., *Use and Misuse of Land.*

Gregory, G.R., 1971, *Forest Products, Production—Trade, Consumption, Quantity and Value of Raw Material Requirements*, Ford Foundation, New Delhi.

Gupta, P.N., 1981, *Hydrology and Forest Influences* (Unpublished).

Howard, Herbert, 1944, *Post-war Forest Policy for India.*

Mann, H.S., Malhotra, S.P. and Shankaranarayanan, K.A. 1977, *Land and Resource Utilisation in the Arid Zone.*

Mishra, N.D., 1978, Hardwoods Pulping and Paper Making—Indian Experience, *Indian Pulp and Paper*, October-November, 1978.

Myrdal, Gunnar, 1968, *Asian Drama: An Enquiry into the Poverty of Nations.*

Nath, V., 1964, *Resource Development Regions and Divisions of India*, Planning Commission, Government of India, New Delhi.

Paterson, S.S., 1956, *The Forest Area of the World and Its Potential Productivity*, The Royal University of Goteborg, Sweden.

Qureishy, I.M., 1968, The Concept of Fast Growth in Forestry and the Place of Indigenous Fast Growing Broad Leaved Species, *Indian Forester*, pp. 51-56.

Randhawá, M.S., 1952, Progressive Desiccation of Northern India in Historical Times, *Indian Forester* (78) 10.

Ranganathan, Shankar, 1980, *The Economics of Forestry.*

Ranganathan, Shankar, 1979, *Agro-forestry & Employment for Millions.*

Romm, Jeff, 1979, *The Uncultivated Half of India*, Ford Foundation, New Delhi (Unpublished).

Saharia, V.B., 1981, Compiled and edited by, Wildlife in India, Published by Department of Agriculture & Co-operation, Ministry of Agriculture, Government of India, New Delhi.

Sagreiya, K.P., 1982, *Forests & Forestry*, India—The Land & People Series, National Book Trust, New Delhi.

Seth, S.K., 1961, *A Review of Evidence Concerning Changes of Climate in India during the Proto-Historical and Historical Periods*, presented to the UNESCO/WMO Symposium on Changes of Climate, Rome.

Seth, S.K., Kaul, O.N. and Sharma, D.C., 1971, *Potential Productivity of Indian Forests*, Paper submitted to International Symposium on "Tropical Ecology Emphasising Organic Production", New Delhi.

Sharma, B.D., 1978, *Forests, Tribal Economy and Regional Development*, Government of India, Ministry of Home Affairs.

Singh, K.N., 1979, *Working Plan of West Dehra Dun Division for 1979-80 to 1988-89*, Uttar Pradesh, Forest Department, Lucknow.

Singh, R.L., 1971, *India, A Regional Geography*, National Geographical Society of India, Varanasi.

Singh, R.V., 1982, *Fodder Trees of India*, Oxford & I.B.H. Publishing Co., New Delhi.

Smythis, E.A., 1925, *India's Forest Wealth.*

Tewari, D.N., 1980, *State Trading in Forest Produce*, Jugal Kishore & Sons, Dehra Dun.

Troupe, R.S., 1940, *Colonial Forest Administration.*

Vijayaraghavachariar, T., 1944, *The Land and Its Problems*, Oxford Pamphlet on Indian Affairs.

Vohra, B.B., 1980, *A Policy for Land and Water*, Sardar Patel Memorial Lectures, Government of India, Department of Environment.

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ERRATA

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List of abbreviations	4	1,000,000	10,000,000
14	2	000 ha	m ha
16	4	ha	m ha
26	6	axis	axes
32	11	ex-offcio	ex officio
43	3	moisture	more moist
65	3	factor	factors
129	Column^5	metre m^3	m $metre^3$
135	1	badies	bodies
147	5	cocoanut	coconut
151	18	*tilda*	*tulda*
164	30	*decuarens*	*decurrens*
201	12	105	80
205	34	7	delete
215	18	There	Three
231	3	Kenya.	Kenya,
239	Last line	and Orissa	delete
250	4	Add million after 240	
255	18	brother	brothers
271	1	Derivative	Derivatives
277	2	prohylactic	Prophylactic
340	43	Goorie	Gorrie

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